Understanding Social Media and Mass Mobilization in the Operational Environment

A Monograph

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In some cases, intelligence analysts can predict or anticipate effects based on simple pattern analysis or other predictive models. In other instances, this may prove impossible. The US Army may find that using principles of complexity theory can provide the most continuously useful guide to gain insights into how factions intent on social unrest use social media to help organize their movements and advance towards a common goal. Planners can understand potential threats using characteristics of self-organization, anticipate using emergent properties, and exploit the properties of networks inherent in complex adaptive systems. Using complex systems thinking, the Army may be able to develop unique operational approaches to cope with these problems in an increasingly complex environment.

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Abstract

Understanding Social Media and Mass Mobilization in the Operational Environment, by MAJ Phillip Cain, 67 pages.

The advent of social media combined with unfettered access to inexpensive mobile electronic devices has dramatically increased information sharing throughout populations worldwide. Journalists ascribed terms such as “The Facebook Effect” and “The Twitter Revolution” to recent uprisings in the Middle East, crediting social media as a catalyst to those social movements. Factions demanding change utilized social media to assist in mobilizing activist crowds within their own countries and to garner support on the international stage. The degree to which social media facilitated these movements varied in each country, but the fact that social media played a role in the uprisings is indisputable. This monograph proposes that since people will continue to use social media to help influence future social movements, the US Army needs to better understand, anticipate, and exploit the potential threat presented by social media and mass mobilization in future operating environments.

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Acronyms

ADP	Army Doctrine Publication
ADRP	Army Doctrine Reference Publication
CAS	Complex Adaptive System
DSCA	Defense Support to Civil Authorities
FTP	File Transfer Protocol
ICT	Information Communication Technology
IS	Islamic State
TRADOC	Training and Doctrine Command
UNICEF	United Nations Children's Fund
UNR	United Nations Resolution

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Introduction

The advent of social media combined with unfettered access to inexpensive mobile electronic devices has dramatically increased information sharing throughout populations worldwide. Journalists ascribed terms such as “The Facebook Effect” and “The Twitter Revolution” to recent uprisings in the Middle East, crediting social media as a catalyst to those social movements. Factions demanding change utilized social media to assist in mobilizing activist crowds within their own countries and to garner support on the international stage. The degree to which social media facilitated these movements varied in each country, but the fact that social media played a role in the uprisings is indisputable. This monograph proposes that since people will continue to use social media to help influence future social movements, the US Army needs to better understand, anticipate, and exploit the potential threat presented by social media and mass mobilization in future operating environments.

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Background

The impact of social media on the operational environment is not a new subject in 2015. Journalists, researchers, and students have followed the evolution of social media and its influence on society and contentious politics. In the immediate aftermath of the Arab Spring,

journalists and executive officers of social media businesses initially claimed that protesters owed the success of the uprisings and overthrow of established governments to the use of social media to mobilize crowds, incite them, and provide direction during mass demonstrations.[1] Journalists exaggerated the initial credit to social media, failing to give recognition to traditional methods of communication, historical examples of government overthrow using mass mobilization prior to the use of mobile devices and social media, and the effects of government policies that helped create the impetus for the dissatisfaction among the populace.[2]

Studies have been conducted to account for social media's ability to enhance mass mobilization, citing the need for modern militaries to account for this new phenomenon. Using simple evaluation methods or social movement theory, they have shown how the use of common open-source social media provides critical insights into the operational environment.[3] All of these methods are valid and help in the analysis of this element of social unrest; however, a gap in research exists in using principles of complexity as a lens to analyze this topic. Mass mobilization fueled by social media makes the potential problems for governments and security forces more complex. As the combination of these concerns mirror the nature of complex adaptive systems, principles of complexity can provide a valid framework to analyze historical examples of

[1] "Social Media and the Arab Spring: Revolution, Censorship, and Freedom," hosted by Helle C. Dale, aired February 13, 2013, on The Heritage Foundation, accessed December 9, 2014, http://www.heritage.org/events/2013/02/social-media-and-the-arab-spring.

[2] Anthony H. Cordesman and Nicholas S. Yarosh, "The Causes of Stability and Unrest in the Middle East and North Africa: An Analytic Survey," Center for Strategic & International Studies, February 13, 2012, accessed November 13, 2014, http://csis.org/publication/causes-stability-and-unrest-middle-east-and-north-africa-analytic-survey, 4.

[3] Madeline Storck, "The Role of Social Media in Political Mobilisation: A Case Study of the January 2011 Egyptian Uprising," (master's diss., University of St Andrews, Scotland, 2011), accessed March 22, 2015, http://www.culturaldiplomacy.org/academy/content/pdf/participant-papers/2012-02-bifef/The_Role_of_Social_Media_in_Political_Mobilisation_-_Madeline_Storck.pdf, 24-32; Justine S. Krumm, "The Influence of Social Media on Crowd Behavior and the Operational Environment," (monograph, School of Advanced Military Studies United States Army Command and General Staff College, 2013), accessed August 10, 2014, http://www.dtic.mil/get-tr-doc/pdf?AD=ADA587347, 7-15.

government overthrow using social media to spur mass mobilization, and will help planners to understand and exploit future occurrences. By viewing social media and mass mobilization as a complex adaptive system, and by focusing on basic properties of complexity—self-mobilization, emergence, and network principles—a planner can better understand, anticipate, and ultimately exploit potential threats that traditional scientific models are unable to predict.

Complex system analysis may provide a useful tool for military planners tasked with developing plans for operating inside and around foreign cities as well as for US National Guard units conducting defense support to civil authorities (DSCA) missions inside of the United States. Individual empowerment, proliferation of mobile devices, and increased use of social media networks are all on the rise, indicating a need to understand how the interaction of these trends may present challenges to the US Military in future operating environments. For the past 15 years, disgruntled populations engaged in contentious politics have utilized social media to support mass mobilizations with mixed results, mainly against local and federal governments.[4] The success or failure of the efforts did not necessarily hinge on the use of social media, but had more to do with the strength of the organizations that employed social media—in relation to the government—to increase the scope of their movement and speed of mobilization.[5] In a documented briefing by the RAND Corporation, John Arquilla and David Ronfeldt stated how organizations successfully brought change to their government:

> Thus, although the social revolutions of 1848 all failed, the Mexican and Russian Revolutions of the early 20th century, occurring but a few years apart, were wildly successful. These revolutions involved an emphasis on the creation of mass organizations that could hold mass demonstrations, but they were also the harbingers of 'maneuver-oriented' social revolutions.[6]

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[4] Clay Shirky, "The Political Power of Social Media," *Foreign Affairs*, no. 90 (Issue 1): 28-41, accessed September 13, 2014, http://www.foreignaffairs.com/articles/67038/clay-shirky/the-political-power-of-social-media paragraphs 5-7.

[5] Ibid., 7.

[6] John Arquilla and David Ronfeldt, "Swarming and the Future of Conflict" (documented briefing, RAND Corporation National Defense Research Institute, 2000), 20.

If mass demonstrations were key to the downfall of powerful regimes, then the infusion of social media to help grow social movements at speeds previously unexperienced in history serves as a harbinger for any government concerned about its country's stability. Clay Shirky, a consultant and teacher on the effects of internet technologies, noted, "as the communications landscape gets denser, more complex, and more participatory, the networked population is gaining greater access to information, more opportunities to engage in public speech, and an enhanced ability to undertake collective action."[7] Prior to the Arab Spring in 2010, protesters have increasingly used technology and communication devices to spur action among the population.

One of the earliest connections of social media and contentious politics occurred in 2001. Citizens in the Philippines, angry that the court dismissed crucial evidence against their President Joseph Estrada, forwarded text messaging stating "Go 2 EDSA. Wear blk [*sic*]."[8] The crowd continued to grow to over a million people during the next several days. The crowd's effort proved successful in overturning the legislator's decision regarding dismissing evidence during the president's impeachment trial, which ultimately forced the president out of office, just a few days after the mass mobilization ensued. Demonstrators forwarded emails and texts to contact the largest possible audience in the shortest amount of time, with minimal effort.

Protestors in Spain adopted the strategy that proved successful in the Philippines, and they succeeded in removing their Prime Minister, Jose Maria Aznar in 2004. In 2006, protests in Belarus, arranged in part by forwarded e-mails, failed to depose their president, Aleksandr Lukashenko. Three years later, in 2009, the communists lost power in Moldova after protesters used texts, Facebook, and Twitter to dispute fraudulent elections. The 2009 Green Movement in Iran and the 2010 Red Shirt uprising in Thailand both used available forms of social media, but

[7] Shirky, paragraph 4.

[8] Ibid., paragraph 1.

their respective governments used violent means to kill protesters and disperse the crowds.[9] The successful historical efforts of mass mobilization supported by mass media does not rely solely on the strength of the existing organizations, but also hinges on the willingness of those in power to use extreme violence against their own citizens to quell protests.

The increased use of social media in the socio cultural environment and the emergence of its role in popular uprisings will most likely continue with increased frequency with the proliferation of internet and mobile devices to remote areas of the world. Former US Secretary of Defense Robert Gates commented on a surprising event in Afghanistan. "It could have been a scene out of the eighteenth century—until one of the elders told me he had read my recent Kansas State University lecture on soft power on the internet. It was a useful reminder that traditional customs and dress do not equate with technological backwardness."[10] An increasingly connected world portends environments with an increased ability for people to reach large audiences with their message, both within their own country, and to internationally sympathetic audiences.

Understand, Anticipate, Exploit Using Principles of Complexity Theory

Robert Axelrod and Michael D. Cohen, authors of *Harnessing Complexity* believe that "complexity research gives us a grounded basis for inquiring where the 'leverage points' and significant trade-offs of a complex system may lie. It also suggests what kinds of situations may be resistant to policy intervention, and when small interventions may be likely to have large effects."[11] Using principles of complexity theory, this paper will analyze how to understand, anticipate, and exploit mass mobilization facilitated by the use of social media. Contemporary

[9] Shirky, paragraph 6.

[10] Robert M. Gates, *Duty: Memoirs of a Secretary at War* (New York: Random House Inc., 2014), 211.

[11] Robert Axelrod and Michael D. Cohen, *Harnessing Complexity: Organizational Implications of a Scientific Frontier* (New York, NY: Basic Books, 2000), 21.

mass mobilization relies on social media, and so any analysis of future mass mobilization without considering social media as a central component would lead to an incorrect analysis. This paper will weight its efforts towards the social media component, but will reference the concept of mass mobilization and crowds when appropriate. After clarifying some basic terms for the discussion, this paper will justify the need for the US Army to better understand this potential threat, based on expected future operating environments. Using the Army's own expectation of future environments, as well as trends including urbanization, mobile electronic device proliferation, and social media use, this paper will demonstrate the relevance of this subject for the Army's consideration.

Properties common to complex systems—simple components of agents, nonlinear interactions among components, absence of central control, and emergent behaviors—provide a basis for the following analysis of mass mobilization and social media. There are several institutions of higher learning that focus solely on the study of complex system science. As it is an evolving and multidisciplinary field, there are some differences in the identification of common principles. To prevent shifting between definitions and principles of the various institutions, this paper will rely on the material the Santa Fe Institute developed as a basis for the complexity theory principles.[12] Two of the four properties common to complex systems will be expanded in the analysis of understanding and anticipating potential threats presented by mass mobilization and social media. The third property common to complex systems, "absence of central control," will assist in understanding the concept of self-organization within the system. The fourth property of complex systems, "emergent behavior," will provide a basis for analyzing how to anticipate the system. The last section of analysis will use the properties of networks in complex adaptive systems to suggest ways of exploiting the system.

[12] Melanie Mitchell, "Introduction to Complexity" (video of Santa Fe Institute lecture series, Fall 2014), *Complexity Explorer*, accessed November 3, 2014, http://www.complexity explorer.org. Registration and login required for the course offered through the institute.

This monograph will draw on examples from the events surrounding the Egyptian uprisings and eventual overthrow of the Egyptian government in 2011 as a specific mass mobilization case study to relate to the principles of complexity. This method of investigation will be used throughout the "Understand" and "Anticipate" sections of this paper. Conceptual ideas, rather than historical examples, will be used in the "Exploit" section of this paper. Each potential future incident provides a unique context, so some characteristics and principles mentioned here may not apply to each situation. It is up to the planner to identify which principles are relevant, based on the specific situation, and use the appropriate complexity principles to understand, anticipate, or exploit threats in their environment.

Defining Terms

Over the years, new terms related to popular mobilizations have developed, while some old terms have taken on new meanings. This section will define terms for use in the rest of this paper, to ensure a common understanding. Terms such as popular mobilization, social mobilization, mass mobilization, contentious politics, social swarm, and battleswarm are terms that generally relate to mobilizing people towards a common goal. The next section will cover the terms related to media and its use. These terms include information communicating technology, social media, and new media.

For purposes of this discussion, this paper uses "popular mobilization" as an umbrella term that includes the remaining terms in this paragraph. The United Nations International Children's Emergency Fund (UNICEF) describes social mobilization as a broad scale movement to engage people's participation in achieving a specific development goal through self-reliant efforts.[13] This paper views social mobilization as an inherently non-violent means for change in a

[13] "Social Mobilization," UNICEF, accessed October 8, 2014, http://www.unicef.org/cbsc/index_42347.html.

community primarily in post-disaster and post-conflict recovery and reconstruction. Traditional dictionaries do not define the term "mass mobilization." An online dictionary defines mobilize as "[bringing] people together for action," and "making soldiers or an army ready for war."[14] A contemporary definition of mass mobilization refers to bringing together civilian populations specifically, as part of contentious politics. "Mass mobilization is often used by grassroots-based social movements, including revolutionary movements, but can also become a tool of elites and the state itself. The process usually takes the form of large public gatherings such as mass meetings, marches, parades, processions and demonstrations. Those gatherings usually are part of a protest action."[15] The *Wiley Blackwell Encyclopedia of Social & Political Movements* defines contentious politics as the "episodic, public collective interaction among makers of claims and their objects."[16] In an article titled "Social Swarming", Air Force Major and public affairs officer, Major David Faggard, describes social swarming as "more than using the Internet or social media; it entails network envelopment of the information aspect of modern command and control. These complex networks are optimal when fully connected and flat with opportunity for direct 'horizontal communication' between network peers."[17] John Arquilla and David Ronfeldt of the RAND Corporation introduced the term "battleswarm" as an operational concept for network-

[14] "Mobilizing," *American Heritage Dictionary of the English Language*, 5th ed., accessed October 8, 2014, http://www.thefreedictionary.com/mobilizing.

[15] "Mass Mobilization," *Wikipedia*, last modified November 29, 2014, accessed November 30, 2014, http://en.wikipedia.org/wiki/Mass_mobilization.

[16] "Contentious Politics," *Wiley Blackwell Encyclopedia of Social & Political Movements*, January 14, 2013, accessed November 10, 2014, http://onlinelibrary.wiley.com/doi/10.1002/9780470674871.wbespm051/abstract.

[17] David Faggard, "Social Swarming: Asymmetric Effects on Public Discourse in Future Conflict," Military Review (March-April, 2013): 80, accessed November 10, 2014, http://www.readperiodicals.com/201303/2962574921.html.

centric distributed maneuver. This concept will be covered later in this monograph in more detail.[18]

Information Communication Technology (ICT) "is an umbrella term that includes any communication device or application, encompassing: radio, television, cellular phones, computer and network hardware and software, satellite systems and so on, as well as the various services and applications associated with them, such as videoconferenceing and distance learning."[19] Social media is a subset of the overarching ICTs. The first known use of the term social media was in 2004 and includes "forms of electronic communication . . . through which users create online communities to share information, ideas, personal messages, and other content."[20] New media is a term that relates to any developing forms of electronic media and exists as a subset of social media.

Relevance of Social Media and the Army's Future Operating Environment

The potential for the diffusion of power from the traditional state structure to groups inside of the state and transnational organizations is a growing trend.[21] Strategic commentator Joseph Nye stated, "In an information-based world of cyberinsecurity, power diffusion may be a greater threat than power transition."[22] The Oxford Handbook of Modern Diplomacy describes a power shift from club to network diplomacy. "The former is based on a small number of players, a highly hierarchical structure, based largely on written communication and on low transparency;

[18] Arquilla and Ronfeldt, iii.

[19] Margaret Rouse, TechTarget, accessed November 15, 2014, http://searchcio.techtarget.com/definition/ICT-information-and-communications-technology-or-technologies, paragraph 1.

[20] "Social Media," *Merriam-Webster*, accessed November 15, 2015, 2014, http://www.merriam-webster.com/dictionary/social%20media.

[21] Joseph S. Nye, Jr., *The Future of Power* (New York, NY: PublicAffairs, 2011), 113.

[22] Nye, xii.

the latter is based on a much larger number of players (particularly of civil society), a flatter structure, a more significant oral component, and greater transparency."[23] Writers of the first US Quadrennial Diplomacy and Development Review acknowledged these trends and suggested additional focus on development in fledgling countries. Leading through civilian power was a central theme, supported by transnational institutions.[24] Diffusion of power from the traditional state structure points to the potential increased power and influence of individuals and distributed networks within states and even across state boundaries. This future indicates fertile ground for those interested in making changes in their government through social unrest, as they will be able to grow a larger support base inside and outside of their country in shorter time spans.

Increased urbanization will require the US Army to operate in cities

The National Intelligence Council expects urbanization to continue to increase to 2030 and beyond.[25] The 2012 study indicated that of the estimated 8.3 billion people on the earth in 2030, sixty percent will live in urbanized areas and migration to urbanized areas will continue to increase.[26] Additionally, the US Army's Training and Doctrine Command's (TRADOC) *Intelligence Assessment of the Operational Environment to 2028* increasingly expects the US

[23] Andrew F. Cooper, Jorge Heine, and Ramesh Thakur, "Introduction: The Challenges of 21st-Century Diplomacy," in *The Oxford Handbook of Modern Diplomacy*, August 2013, accessed November 4, 2014, http://www.oxfordhandbooks.com/view/10.1093/oxfordhb/9780199588862.001.0001/oxfordhb-9780199588862-e-1, first paragraph.

[24] US Department of State, *Leading through Civilian Power: The First Quadrennial Diplomacy and Development Review*, 2010, accessed September 24, 2014, http://www.state.gov/documents/organization/153108.pdf, ii-iv.

[25] US Office of the Director of National Intelligence, *Global Trends 2030: Alternative Worlds, a publication of the National Intelligence Council*, December 2012, accessed September 24, 2014, https://cgsr.llnl.gov/content/assets/docs/Global_Trends_2030-NIC-US-Dec12.pdf, iv.

[26] *Global Trends 2030*, 7.

Army to operate inside of cities with large populations.[27] Individual empowerment in these cities is accelerating. As poverty rates decrease and electronic devices become less expensive, the demand for mobile electronic devices will continue to grow, giving new customers immediate access to the internet. More people connected to the internet means a higher population of users who social media can affect through messaging. This increases the potential for more efficient mass mobilization among populations dissatisfied with their government and interested in social change. Increased urbanization has prompted the US Army to investigate how it can operate inside of large cities, a dramatic shift from the historical and current US Army's experience. To be successful in this type of future operating environment, the Army must understand how populations use social media to engage in social unrest and contentious politics that lead to mass mobilization.

Social media trends

Mobile phone usage is increasing across the globe, even in underdeveloped nations in regions such as Africa and the Middle East. Mobile phone owners in the combined region of Africa and the Middle East will double in the coming years. By 2017, the Asia-Pacific region will have almost three billion mobile phone users, while the Middle East and Africa will grow to 670 million. Latin America will boast 471 million users; Central and Eastern Europe will grow to 367 million; Western Europe will have 360 million; and North America will round out at 287 million. This will bring the worldwide total mobile phone usage to over five billion people.[28] Increased

[27] Training and Doctrine Command (TRADOC) G-2, *Operational Environments to 2028: The Strategic Environment for Unified Land Operations*, August 2012, accessed October 5, 2014, http://www.defenseinnovationmarketplace.mil/resources/TRADOC2028_Strategic_Assessment.pdf, 24.

[28] "eMarketer Roundup: Global Media Trends," April 2014, accessed November 1, 2014, http://www.festivalofmedia.com/media/10971/eMarketer_FOM_Global_Roundup.pdf, 7-12.

mobile phone ownership increases the ability to spread information quickly across demographics inside of a country, as well as to the international community.

The trend for average time spent per day on digital activities in the United States has dramatically increased from 2010 to 2013. Smartphones and tablets are replacing the laptop and desktop as the primary means of interacting with social media, indicating an increasingly mobile access to social media networks.[29] The future of social media and mobile electronic devices will not slow. In 2014, Apple introduced a watch designed to give consumers constant access to their mobile networks. Trends indicate a rising number of mobile devices with increased connectivity as more data towers and Wi-Fi hot spots become available, all leading to increased mobile social media usage across the globe.[30]

In 2014, Facebook, Twitter, LinkedIn, YOUTube, Google+, and Pinterest were the top companies, in that order, used by marketers to make contact or sustain contact with their customers. Instagram took the eighth slot and showed the highest increase from 2013 to 2014. Potentially important to this study are geo-location applications, such as foursquare, used by approximately twelve percent of marketers.[31] eMarketer, a research firm focused on collecting business marketing statistics, analyzed data points across the digital marketplace, and assessed that "fragmented multiscreen media consumption has left marketers struggling to keep up or get a word in edgewise. Social networking appears to be the glue that binds together the experience of

[29] "eMarketer Roundup," 8. The study was conducted on individuals eighteen and older. Social network advertisement spending is increasing worldwide, indicating that for-profit businesses believe that the consumer market is increasingly connected to mobile social media devices.

[30] "eMarketer Roundup," 3.

[31] Michael A. Stelzner, "2014 Social Media Marketing Industry Report: How Marketers Are Using Social Media to Grow Their Businesses," Social Media Examiner, May 2014, accessed September 13, 2014, http://www.socialmediaexaminer.com/SocialMediaMarketingIndustry Report2014.pdf, 23.

multiple device usage."[32] Companies in countries outside of the United States are also developing their own social media sites. QQ, a Chinese instant-messaging service, Tuenti, a Spanish social network, and Naver, a Korean social network are examples of popular social networks in foreign countries.[33] US companies that dominate the current market could experience a drop in their overseas market as more countries develop social media networks designed to draw their own customer base. This would reduce US social network companies' ability to limit certain types of global communication, such as terrorist activity, as individuals find other venues for recruiting and broadcasting their message.

Use of videos in social networking activities has also grown exponentially. Words paint a picture and convey meaning, but video intensifies the message, especially if the video is provocative in nature. For example, the YouTube video of the Tunisian market vender, Mohamed Bouazizi setting himself on fire, added an emotional component that a newspaper article could not achieve.[34] eMarketer analysts stated, "the big shift is the water cooler conversation that once took place the next day at the office now takes place online, in real time. And an increasing portion of that real-time conversation centers around video. In this way, social and video content help connect consumers' cross-device interactions."[35] Media savvy individuals in the Islamic State (IS) understand this trend and have increasingly displayed terrorist acts on social media networks to advance their message and expand their social reach.[36] IS' successes in recruiting

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[32] "eMarketer Roundup," 3.

[33] Shirky, paragraph 4 of the section "Looking at the Long Run."

[34] Rania Abouseid, "Bouazizi: The Man Who Set Himself and Tunisia on Fire," *Time*, January 21, 2011, assessed December 8, 2014, http://content.time.com/time/magazine/article/0,9171,2044723,00.html.

[35] "eMarketer Roundup," 3.

[36]Con Coughlin, "How Social Media is Helping Islamic State to spread its Poison," *Telegraph*, November 5, 2014, accessed March 5, 2015, http://www.telegraph.co.uk/news/uknews/defence/11208796/How-social-media-is-helping-Islamic-State-to-spread-its-poison.html, paragraph 7.

individuals inside of the countries they occupy and abroad, using increasingly sophisticated videos, messaging, and editing, will most likely be replicated by other groups desiring more publicity and international attention in the future.

Several Fortune 500 companies have realized the need to monitor social media in real time to determine how media campaigns and selections of spokespeople affect their brand. This enables the companies to make instant marketing changes to prevent a bad marketing campaign from negatively affecting their brand. Several years ago, PepseCo's sports drink brand, Gatorade, developed the Gatorade Mission Control Center, and placed it in the center of its marketing department at its Chicago headquarters to monitor its brand in real-time. It not only tracts anything related to its brand, the team also tracks competitors. In fact, people refer to the control center as a "war room," borrowing a term from the room that the President of the United States uses to monitor strategic operations.[37] Other companies have noticed the benefit and have followed suit, creating their own social media command centers to help manage the task of integrating their communication and marketing with the ever-increasing social media networks. In 2014, Wendy Parish from MarketingDIVE reported on five companies that have developed social media command centers, dedicated to slightly different tasks, but all geared towards tracking and integrating with social media and their customers. Some use the command center to interact with customers to provide immediate responses to customer inquiries; others centrally locate the room to allow casual access to company employees to provide insight and customer reaction to their projects.[38] Civilian companies understand that they work in a complex business

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[37] Adam Ostrow, "Inside Gatorade's Social Media Command Center," *Mashable*, June 15, 2010, accessed 5 February 2015, http://www.mashable.com/2010/06/15/gatorade-social-media-mission-control/.

[38] Wendy Parish, "These 5 Companies have Social Media Command Centers Down to a Science," *Marketing DIVE*, April 17, 2014, accessed February 5, 2015, http://www.marketingdive.com/news/these-5-companies-have-social-media-command-centers-down-to-a-science/251722/.

environment, and with the increase of mobile devices and changes in social media, they are working to adapt to their customers' changing behavior patterns.

Social media is changing the way populations share information, network, and mobilize. The Army will have to find new ways of operating in cities with increasing numbers of disaffected youth armed with smart phones and extended social media networks.[39] US decision-makers may ask the US military to respond to failing states and to help stabilize their governments. Thomas Friedman, author of *The World is Flat,* described the combination of personal emotions and access to the internet this way:

> The product of a convergence of the personal computer (which allowed every individual suddenly to become the author of his or her own content in digital form) with fiber optic cable (which suddenly allowed all those individuals to access more and more digital content around the world for next to nothing) with the rise of work flow software (which enabled individuals all over the world to collaborate on that same digital content anywhere, regardless of the distances between them).[40]

To effectively operate in countries with failing states, the US Army will need to know how to operate inside of large cities with populations that may be weary of US presence. One of the common themes across the uprisings in the last five to ten years is the ease with which groups have gathered large crowds of people. The demonstrators have been able to accomplish major rallies without their government anticipating the size and scale of the protests, making it difficult for security forces to cope with the problem.[41]

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[39] Rory Lidstone, "Smartphone Users Pass the 30 Million Mark in South Korea," Mobility Techzone, August 22, 2012, accessed August 9, 2014, http://www.mobilitytechzone.com/topics/4g-wirelessevolution/articles/2012/08/22/304266-smartphone-users-pass-30-million-mark-south-korea.htm.

[40] Thomas L. Friedman, *The World is Flat: A Brief History of the 21st Century* (New York, NY: Ferrar, Straus and Giroux, 2006), 10-1.

[41] James Reynolds, "Turkish Police Tear Gas Protesters on Taksim Anniversary," *BBC*, May 31, 2014, accessed January 3, 2015, http://www.bbc.com/news/world-europe-27649472; Haroon Siddique, Paul Owen, and Adam Gabbatt, "Protests in Egypt and Unrest in Middle East – as it Happened," *Guardian*, May 20, 2014, accessed January 3, 2015, http://www.theguardian.com/global/blog/2011/jan/25/middleeast-tunisia.

Intersection of trends: battleSwarm and possible future of warfare

John Arquilla and David Ronfeldt of the RAND Corporation penned a document in 2000 exploring how the information revolution has introduced a new platform in contentious politics that may also translate to the military profession as a potential doctrine. The authors indicate that the battleswarm, or simply, swarming, could apply to low intensity, civic-oriented actions, all the way to high intensity, military combat.[42] A nation could also employ a combination of the battleswarm docrine supported by a popular mobilization combined with a conventional threat to disrupt US Army operations. While previous forms of warfare increasingly relied on information and the ability to transmit information for synchronized maneuver, the battleswarm depends exclusively on rapid communications.[43] Should the US military have to operate in a largely compliant city of 500,000 people, a mere five percent disaffected population would equal 25,000 possible adversaries who could be quickly mobilized using social media, giving them the potential to overwhelm friendly forces.

The potential for a conventional battleswarm doctrine may be in the distant future, but even if the intersection of the previous trends does not result in a formal battleswarm doctrine, the future environment will involve a non-military or unconventional variety, making the environment more complex. Emile Simpson, the author of *War from the Ground Up*, described contemporary conflict in terms of increasingly fragmented conflict, rather than traditional polarized conflicts of the past. This leads to operating environments where military planners may have a difficult time classifying various actors as either good or bad.[44] In their book *Harnessing Complexity*, Robert Axelrod and Michael Cohen state that

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[42] Arquilla and Ronfeldt, iii.

[43] Ibid., 7.

[44] Emile Simpson, *War from the Ground Up: Twenty-first-century Combat as Politics* (New York, NY: Oxford University Press, 2013), 45.

> if complexity is often rooted in patterns of interaction among agents, then we might expect systems to exhibit increasingly complex dynamics when changes occur that intensify interaction among their elements. This, of course, is exactly what the Information Revolution is doing: reducing the barriers to interaction among processes that were previously isolated from each other in time or space. Information can be understood as a mediator of interactions. Decreasing the costs of its propagation and storage inherently increases possibilities for interaction effects. An Information Revolution is therefore likely to beget a complexity revolution.[45]

The possibility of an adversary using a form of battleswarm doctrine reinforces the US Army's need to understand how social media is used to quickly mobilize and organize people so that it can better understand how to prepare for future challenges. The US Army is currently not prepared for this potential threat. Just one event handled incorrectly could have strategic level consequences for the variety of missions the US Army will conduct in the future. The Arab Spring, and specifically the uprisings in Egypt provide a recent example of a complex environment where actors used social media and emergent tactics to overwhelm Egypt's security forces and government to the point of government collapse.[46]

Overview of Egyptian uprisings in 2011

President Hosni Mubarak reigned over Egypt for thirty years before stepping down in February of 2011, after only eighteen days of demonstrations and protests.[47] The Egyptian uprising was part of a larger movement that spread across a portion of the Arab world. The prelude to Mubarak's fall from power was the revolution in Tunisia where President Zine El Ebinie Ben Ali stepped down from power on January 14, 2011, after twenty-three years in power.

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[45] Axelrod and Cohen, 26.

[46] Craig Kanalley, "Egypt Revolution 2011: A Complete Guide to the Unrest," *Huffington Post*, last modified May 25, 2011, accessed March 19, 2015, http://www.huffingtonpost.com/2011/01/30/egypt-revolution-2011_n_816026.html.

[47] Kanalley, 1.

Tunisia's government was the region's first dictatorship to fall by its own people since 1979.[48] The prelude to Ali's removal from power was the dramatic act and video of a Tunisian street vendor named Mohamed Bouazizi. His self-immolation in December of 2010 prompted a string of protests against the Tunisian government.[49] The dramatic success of the Tunisian protestors inspired protests in other Arab and non-Arab countries in the region, including Egypt, Libya, Yemen, Bahrain, Syria, and others.[50]

The start of the protests with the "day of rage" on January 25, 2011 was not the beginning of the Egyptian people's dissatisfaction with their government and the corruption that surrounded it.[51] The scope of this paper will not allow for a full historical account, but during the beginning of the twenty-first century, people began expressing their discontent with the growing lack of jobs and opportunity.[52] In 2004, an organization grew, bearing the name "Egyptian Movement for Change" with "Enough!" as their unofficial moniker.[53] The Egyptian government responded to the demonstrations, not with reform, but with censoring, characterized by the 2008 court sentence of a journalist by the name of Ibrahim Eissa to six months in prison for reporting on the health of

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[48] Abigail Hauslohner, "After Tunisia: Why Egypt Isn't Ready to Have Its Own Revolution," *Time,* January 20, 2011, accessed March 19, 2015, http://content.time.com/time/world/article/0,8599,2043497,00.html, paragraph 1.

[49] Kareem Fahim, "Slap to a Man's Pride set Off Tumult in Tunisia," *New York Times,* January 21, 2011, accessed March 19, 2015, http://www.nytimes.com/2011/01/22/world/africa/22sidi.html?_r=1&pagewanted=2&src=twrhp.

[50] "Arab Uprising: Country by Country- Tunisia," *BBC,* December 16, 2013, accessed March 19, 2015, http://www.bbc.com/news/world-12482315.

[51] "Timeline: Egypt's Revolution," *AlJazeera,* February 14, 2011, accessed March 19, 2015, http://www.aljazeera.com/news/middleeast/2011/01/201112515334871490.html, 1.

[52] "Timeline: Egypt's Revolution," 1.

[53] Tarek Masoud, "The Road to (and from) Liberation Square," *Journal of Democracy* 22, no. 3 (July 2011): 21, accessed March 19, 2015, http://journalofdemocracy.org/article/road-and-liberation-square, 20. Viewer must subscribe to view entire article.

the autocratic leader.[54] These type of actions characterized the regime's effort to stifle the media and control the regime's narrative. The demonstrations culminated with the death of a young blogger, named Khaled Said, who was brutally beaten and killed after posting and blogging about an incriminating video of police officers in June of 2010.[55]

Growing international attention, fueled in part by Google's Middle East marketing director, Wael Ghonim's effort in setting up a Facebook page with the title of "We Are All Khaled Said" with uncensored pictures of Said's corpse after the beating, helped fuel the discontent and resolve of the protesters.[56] Khaled Said became the Egyptian's version of Tunisia's Mohamed Bouazizi, even though there were six other cases of successful or attempted self-immolations in Egypt during the protests.[57] The harsh response by the government, and those aligned with the government, further angered the protesters, fueling larger and more violent protests.[58] After the first two days of demonstrations, Egyptian officials shut down the internet on January 27, 2011, but beginning on the twenty-ninth, anonymous internet users helped Egyptians to communicate. Egypt announced a new government on the thirty-first and returned internet services two days later. Foreign journalists were rounded up the third, members of the ruling party leadership resign on the fifth, widespread labor strikes continue on the ninth, and Mubarak formally resigned on February 11, 2011.[59] In less than one month of protests, demonstrators successfully removed a thirty-year authoritarian regime from power. The events surrounding the

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[54] Masoud, 20.

[55] Serajul I. Bhuiyan, "Social Media and Its Effectiveness in the Political Reform Movement in Egypt," *Middle East Media Educator*, 1, no. 3 (2011): 17, accessed March 19, 2015, http://ro.uow.edu.au/cgi/viewcontent.cgi?article=1002&context=meme, 17.

[56] Bhuiyan, 17.

[57] Hauslohner, paragraph 10.

[58] Bhuiyan, 17.

[59] Kanalley, 1.

protests, including the increasing interplay of actors and interactions throughout the uprising, provides a modern example through which principles of complexity theory can be used as a lens to evaluate the conditions linking these recent events.

Common Properties of Complex Systems Provide a Basis for Analysis

In 1948, Warren Weaver, an American scientist and mathematician, identified problems with different types of complexity, describing three areas that included: (1) problems with simplicity, (2) problems with disorganized complexity, and (3) problems with organized complexity. He described organized complexity as a group of problems in the middle region between disorganized complexity and simplicity. Organized complexity is where social media and mass mobilization fit. Organized complexity does not contain an infinite number of variables as disorganized complexity, nor does it contain a small number of isolated variables. Weaver wrote, "the problems in this middle region, in fact, will often involve a considerable number of variables. The really important characteristic of the problems of this middle region, which science has as yet little explored or conquered, lies in the fact that these problems . . . show the essential feature of *organization*."[60] This category of complexity provides a framework for the remaining analysis in this paper.

Complexity theory provides a way to harness challenges in a complex environment, instead of attempting to eliminate them. In their book, Axelrod and Cohen explored the dynamic nature of complex adaptive systems to find ways to use complexity for productive ends. They alleged that complex systems, while hard to predict, have some structure that permits adjustment through thoughtful intervention. "One of the benefits of the Complex Adaptive Systems approach is that it helps you see yourself in the context of a population of agents, and helps you see your

[60] Warren Weaver, "Science and Complexity," *E:CO* 6, no. 3 (2004): 65-69, accessed December 9, 2014, http://philoscience.unibe.ch/documents/uk/weaver1948.pdf.

actions in the context of a population of strategies."[61] Using principles of complexity to analyze organized complexity makes it possible to explain behavior patterns of organized groups of people, such as labor unions, manufacturers, or groups desiring social or governmental change.[62]

To understand how planners can use principles of complexity as a lens to recognize patterns in seemingly random behavior that results in mass mobilization of populations, it is important to identify some common characteristics of complex systems. The Santa Fe Institute, an independent, nonprofit research institute has been studying the science of complexity since 1984. The institute describes complex adaptive systems research as a way to "uncover and understand the deep commonalities that link artificial, human, and natural systems."[63] Their research uncovered four commonalities to complex systems that include the following (See Figure 1): (1) simple components or agents, (2) nonlinear interactions among components, (3) absence of central control, and (4) emergent behaviors.[64] The study of complexity and complex adaptive systems is still a relatively new field, and therefore different researchers have suggested other components as common properties to complex systems such as co-evolution, or requisite variety.[65] In an effort to focus this analysis on a limited framework, this paper uses the characteristics outlined by the Santa Fe Institute exclusively. The following section briefly

[61] Axelrod and Cohen, 5.

[62] Melanie Mitchell, "Introduction to Complexity" (video of Santa Fe Institute lecture 1.5 Definitions of Complexity, Fall 2014), *Complexity Explorer*, accessed November 3, 2014, http://www.complexityexplorer.org.

[63] "Frequently Asked Questions," Santa Fe Institute, accessed December 3, 2014, http://www.santafe.edu/about/faq/.

[64] Melanie Mitchell, "Introduction to Complexity" (video of Santa Fe Institute lecture 1.3 Properties Common to Complex Systems, Fall 2014), *Complexity Explorer*, accessed November 3, 2014, http://www.complexityexplorer.org.

[65] Trojan Mice, accessed February 19, 2015, http://www.trojanmice.com/articles/complexadaptivesystems.htm.

describes the common properties to form a basis for a complex system, and how the system relates to social media-driven mass mobilization.

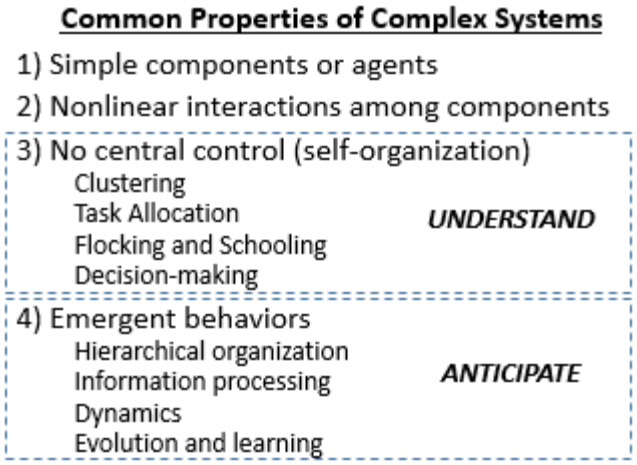

Figure 1. Common Properties of Complex Systems

Source: Created by author, using data from Melanie Mitchell, "Introduction to Complexity" (video of Santa Fe Institute lecture 1.2 Introduction to the Study of Complexity, Fall 2014), *Complexity Explorer*, accessed November 3, 2014, http://www.complexityexplorer.org.

Identify the Simple Components before Analyzing the Interactions

The first property common to complex systems is that the system includes simple components, or agents. They are not simple in isolation; rather, they are simple in relation to the entire system. A flock of blackbirds over a cornfield moving and instantly changing direction can be broken down by analyzing the simple agents as individual blackbirds before attempting to understand the interactions among the individual birds. Simple rules are also common in complex adaptive systems. For example, a rushing river or tumultuous ocean may seem completely chaotic, but identifying a simple rule such as "water always seeks its own level," can begin to bring some understanding to the phenomenon.[66] Simple agents in mass mobilization fueled by

[66] Donald E. Simanek, "Perpetual Futility," accessed January 3, 2015, https://www.lhup.edu/~dsimanek/museum/people/people.htm. Aristotle was accredited with discovering the phenomenon that water seeks its own level.

social media would include the individual people themselves. A simple rule would include the act of communication between those agents, whether it occurred in person, by voice, or through digital means. The organizational behavior develops from the interaction between these agents.

Nonlinear Interactions Create Something Superior to the Individual Components

The second characteristic common to complex adaptive systems is that nonlinear interactions occur among the individual components. The idea behind this characteristic is that the interactions create something greater than the sum of the individual components of the system.[67] Using a sports team as an example, one might take the individual statistics for each player, add them up, and compare them to another team. This is a linear approach to comparing two teams, and does not account for the interactions between the agents in the team. Everett Dolman, former professor of Comparative Military Studies at the School of Advanced Air and Space Studies, described a system with nonlinear interactions by stating:

> It may be in our nature to expect linear relationships. In a linear system, if a little inducement or use of force gets a little of what we desire, then more force will get more of what we want. But in a nonlinear system, we cannot make the same judgment. Sometimes the tiniest amount of additional force will have catastrophic results; other times a great deal of additional force will have no perceptible impact. It may also be that a small amount of the variable can do a great deal of work and then the law of diminishing returns sets in, as is often the case for the role of catalysts. In other cases very little impact is felt until a critical mass is assembled."[68]

Individual agents, not considered a danger in society, may suddenly have an unexpected impact when their interactions among others in the system create an effect greater than the sum of the individual. The effects can come from both the nonlinear interactions of the components and the fact that there is often no central control for the system as a whole.

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[67] Mitchell, Melanie. "Introduction to Complexity" (video of Santa Fe Institute lecture 1.3 Properties Common to Complex Systems, Fall 2014), *Complexity Explorer*, accessed November 3, 2014, http://www.complexityexplorer.org.

[68] Everett Carl Dolman, *Pure Strategy: Power and Principle in the Space and Information Age* (New York, NY: Frank Cass, 2005), 109.

Lack of Central Control Allows for Decentralized Organization

The third property common to complex systems is that central control is nonexistent. This aspect can be one of the most difficult properties to accept, especially for those in a military culture who operate in a very structured and hierarchical system of command. Complex systems do not contain a centralized command, and therefore, it is difficult to anticipate actions made by the system, if viewed from a traditional organizational lens. Instead of information filtered up to a higher-level command, individual components receive information and make changes in a decentralized manner, with the group following suit when the system receives enough pieces of data from individual components. This type of behavior is common among social insects in nature. The queen bee may hold a title common to human social systems, but the queen does not execute any of the traditional roles. Social insects have the ability to move a group in a single direction, or effectively conduct all tasks necessary for the survival of a colony. As Peter Miller, author of *The Smart Swarm* identified*:*

> Social insects such as ants, bees, and termites distribute problem solving among many individuals, each of which is following simple instructions but none of which sees the big picture. Nobody's in charge. Nobody's telling anybody else what to do. Instead, individuals in such groups interact with one another in countless ways until a pattern emerges – a tipping point of motion or meaning – that enables a colony of ants to find the nearest pile of seeds, or a school of herring to dodge a hungry seal.[69]

The Santa Fe Institute identified six properties of self-organization that include flocking and schooling, task allocation, clustering, decision-making, synchronization, and foraging.[70] This paper uses the first four properties to help in understanding how mass mobilization and social

[69] Peter Miller, *The Smart Swarm: How Understanding Flocks, Schools, and Colonies Can Make Us Better at Communicating, Decision Making, and Getting Things Done* (New York, NY: Penguin Group, 2010), xix.

[70] Melanie Mitchell, "Introduction to Complexity" (video of Santa Fe Institute lecture 7.0 Introduction, Fall 2014), *Complexity Explorer*, accessed November 3, 2014, http://www.complexityexplorer.org.

media interact to work towards a common goal. Systems without central control not only survive, but also have the ability to evolve to changing circumstances in their environment.

Emergent Behaviors Lead to Evolution of the System

The fourth and last component, and perhaps the most important, is that complex systems contain emergent behaviors that change over time. Complex systems show a tendency to adapt in ways that people can only understand from an operational level. Using the sports team analogy from the discussion on nonlinear interactions, Jamshid Gharajedaghi, systems engineer and Chief Executive Officer (CEO) of INTERACT, identified different types of nonlinear interactions that would indicate how an organization might react, as a complex system. He showed that an all-star team would not necessarily produce the *best* sport team. A complex systems approach identifies the product of the interactions being more important than the sum of all the statistics of each individual player. For Gharajedaghi, the properties of the whole include the quality of the players *and* the quality of the interactions among them that can produce a spontaneous outcome based on an ongoing process. The system will not act the same in every environment because the emergent property is the result of the system managing all of the interactions within the environment, rather than separately dealing with each individual action.[71] Dolman referenced the same quality of systems, recognizing that local interactions would eventually create a discernable macrobehavior.[72] Emergent behaviors exhibit themselves in multiple ways that include: (1) hierarchical organizations, (2) information processing, (3) dynamics, and (4) evolution and

[71] Jamshid Gharajedaghi, *Systems Thinking,* 2nd ed. (Burlington, MA: Elsevier Inc., 2006), 29, 45-47. Gharajedaghi identified five fundamentals of complex systems that differ from the Santa Fe institute. Both identify emergent properties as a fundamental component; however, Gharajedaghi lists four other system components that include: (1) openness, (2) purposefulness, (3) multidimensionality, and (4) counterintuitive behavior.

[72] Dolman, 114.

learning. Understanding that a complex adaptive system has the tendency to produce emergent behaviors is critical to being able to anticipate action.

Summary of Common Properties of Complex Systems

Viewing social media and mass mobilization as an adaptive system through the lens of the principles of complexity provides just one framework for attempting to understand how the system operates and how the different actors interact within the system. Understanding that complex adaptive systems commonly have simple components or agents and nonlinear interactions among those components, will help us to further analyze the remaining two components, which include the absence of central control and emergent behaviors. This analysis may help a planner to understand and anticipate potential threats presented by mass mobilization and social media.

Understanding how Mass Mobilization and Social Media Interact through Characteristics of Self-Organization

Social animals and insects in nature provide the best examples of systems that exhibit characteristics of self-organization and thrive without central control. The Santa Fe Institute described self-organization as the "production of organized patterns, resulting from localized interactions within the components of the system, without any central control."[73] Social insects are surprisingly adept at self-organization. Characteristics of self-organization offer a way to understand how groups of people can organize and rally towards a goal without clearly identified leaders. For this discussion, characteristics of self-mobilization include: (1) clustering,

[73] Melanie Mitchell, "Introduction to Complexity" (video of Santa Fe Institute lecture 7.0 Introduction, Fall 2014), *Complexity Explorer*, accessed November 3, 2014, http://www.complexityexplorer.org.

(2) flocking and schooling, (3) task allocation, and (4) decision-making. This section will not analyze the other two characteristics of self-mobilization identified by the Santa Fe Institute: synchronization and foraging. The four listed here relate best to social media and mass mobilization. In this section, the characteristic of self-mobilization will be defined, followed by an example in nature to further develop the concept, then the concept will be applied to the analysis of mass mobilization and social media using examples from the Egyptian uprisings to support the analysis. This analysis will show how social media-driven mass mobilization operates as a complex adaptive system, using common characteristics self-organization, rather than a rigid top-down structure, to accomplish tasks and reach organizational goals.

Clustering Helps Protect Individuals

Clustering primarily serves to protect individual organisms in a group. Clustering helps groups to recognize a potential threat sooner, since multiple pairs of eyes are likely to spot a predator—and sooner—than a single pair. If a predator attacks a cluster of animals, it is much easier to get lost in a crowd of individual animals. The animal on the outskirts or the one lagging behind the group is often the one that the predator eats, so there is an inherent security in the cluster.[74] The higher number of statistics that an individual organism receives, the better it is able to make a decision on which direction to move to stay in a zone of safety. Each individual needs to make a decision based on movement of those closest to it, and so eventually, the system displays a threshold response. “If you’re a fish in this big group and one individual goes off, you don’t follow it. But if two individuals go off within a short time period of each other, then you have this cascade, and you all go.”[75]

[74] Miller, 212.

[75] Ibid., 205-206.

In popular mobilization, safety inside of the cluster is important for those who might consider joining in with protests. Often, the willingness of those in power—whether in a democracy, dictatorship, or autocracy—to harm those people conducting the protest becomes an important consideration. Individuals that may get involved with contentious politics, especially mass mobilization with the intent to cause destruction to produce a political result, desire some type of safety. This may not be as important of a consideration for the individuals unwaveringly committed to one side of the issue or the other, but it does become a consideration of primary importance for those individuals in the middle somewhere.[76] Before the introduction of social media, including mass emails, it was difficult to determine the scope of planned events, from a protester's perspective, making the decision to join the protest more risky. For those in the middle considering getting involved, social media has decreased the uncertainty of possible low numbers of protesters.

People following Facebook leading up to the January 25, 2011 protest in Egypt began signing up online, leading up to 100,000 people who actually signed up to be part of the protest before the protest occurred. The increasing number of people signing up, pledging to be at the protest, and even uploading videos of themselves and encouraging others to commit, reduced the perceived cost of joining in the protest for the same reason that individual animals join in a cluster for protection. Individuals realized that "their opinions were shared by hundreds of thousands," which helped motivate Egyptians to action.[77] According to Jeroen Gunning and Ilan Zvi Baron, authors of *Why Occupy a Square*:

> One of the major obstacles to mass protest is ubiquitous preference falsification: individuals who detest the regime refrain from making their views public out of fear of either social or official sanction. On this view, the increased public incidence of

[76] Susanne Lohmann, "The Dynamics of Informational Cascades: The Monday Demonstrations in Leipzig, East Germany, 1989-91," *World Politics* 47, no.1 (October 1994): 47, accessed February 13, 2015, http://www.sscnet.ucla.edu/polisci/faculty/chwe/ps269/lohmann.pdf.

[77] Jeroen Gunning and Ilan Zvi Baron, *Why Occupy a Square? People, Protests and Movements in the Egyptian Revolution* (New York, NY: Oxford University Press, 2014), 289.

> oppositional views online helps to encourage others who privately hold such views to express them in public.[78]

The principle of clustering in self-organization within complexity theory is an important consideration in understanding how social media can play a critical role in the momentum of protests. Social media helps to increase the size of the initial protest, and then helps grow the protests as the feeling of safety increases as the size of the expected future protests increases, drawing those in the middle who might have stayed home.

Flocking and Schooling Assists in Moving Towards a Common Objective

Flocking and schooling share some of the same characteristics as clustering for animals and insects. Flocking and schooling is the second characteristic of self-organization within a system and benefit social animals and insects in several ways. First, predators believe they cannot target a flock or school of animals because they can misinterpret it as a large or threatening organism. Not only do they not target the group, they may go to lengths to avoid it. Even when predators understand that the flock or school is a group of many individual organisms, they may not be able to successfully target individuals in the flock or school. When hunting, groups of organisms find flocking or schooling to be more efficient at catching prey via cooperative hunting, rather than relying on individual efficiency. The flock or school can also increase the individual organism's aero or hydro-dynamic efficiency.[79] The individual organisms can occasionally break apart from the flock or school for a variety of reasons, but the desire is to remain with the larger group.

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[78] Gunning and Baron, 289.

[79] Melanie Mitchell, "Introduction to Complexity" (video of Santa Fe Institute lecture 7.2 Flocking and Schooling, Fall 2014), *Complexity Explorer*, accessed November 3, 2014, http://www.complexityexplorer.org.

The characteristics of flocking or schooling apply to large crowds of people, especially when the desire of the group is some type of social unrest and individuals in the crowd believe they may be in danger of civil punishment or physical harm. Security forces certainly would not believe that the group of people was actually a large organism, but the large group does make it more difficult to target an individual, particularly when the large group is moving and significantly outnumbers the security forces. As long as individuals in the group stay within close proximity of others in the group, it makes it difficult to isolate one or just a few members of the group. Crowd swarming in the digital realm can provide the same feeling of security. Sometimes individuals can even congregate or add to online activity in an anonymous fashion, thereby giving more credibility to the movement with increased numbers, without making themselves a target. Even when not anonymous, the US constitution provides security for individuals with freedom of speech laws. Other countries do not have the same freedoms of political speech. China, for instance, recently closed internet social accounts that originated from an alias, in an effort to help identify those who become involved in creating social unrest.[80] A large group of people could also have a cognitive or physical effect on their surrounding that they would not be able to achieve on their own, which explains why flocking and schooling is important. Scientists and engineers have researched how self-organized groups of organisms employ this technique for the benefit of their group.

Craig Reynolds, software engineer, developed the "Boids" model that explained how flocks and schools operate, from very simple rules that include collision avoidance, velocity matching, and flock centering.[81] Collision avoidance involves the simple act of maneuvering

[80] Steven S. Roach, "China's Connectivity Revolution," *AlJazeera*, January 29, 2012, accessed February 5, 2015, http://www.aljazeera.com/indepth/opinion/2012/01/20121 2895329172118.html.

[81] Craig W. Reynolds, "Flocks, Herds, and Schools: A Distributed Behavioral Model," *Computer Graphics* 21, no. 4 (July 1987): 25-34, accessed November 5, 2014, http://www. cs.toronto.edu/~dt/siggraph97-course/cwr87/.

away from an anticipated collision. Velocity matching indicates that individual organisms will adjust their speed to match the speed of those closest to it, which keeps a whole flock or school at a similar speed. Flock centering means the individual organism attempts to be at the center of nearby similar organisms in a localized setting, which keeps a large group together. These rules prove simple enough that computer models and simulations can replicate flocking and schooling actions, even though the movements as a group seem chaotic.

Crowds of people operate in similar ways as flocks and schools, using individual rules that result in movement as a large group. Physical collision avoidance is common among individuals in a group and can keep a group moving in a direction without crushing individuals inside of the group. Velocity matching to individuals in close proximity keeps a group together, while moving. Without any individual leader, the group can begin moving or come to a halt, using the same basic rules of flocking and schooling. Individual desires to keep within a group show how flock centering applies to large groups of people as well, and is also related to the digital realm with types of social swarming.

In 2009, Geoff Hughes, Client Services Account Director at Nudge Social Media, defined crowd swarming as "when a multitude of people, connected socially through social media, move as if en masse over a very short [time span] towards the same target digital content. The rapid ability for people to share without having to think . . . means that crowds of people swarm en masse towards a target that captures global interest within minutes."[82] People can connect around a common interest in a very short time period, normally through existing contacts, friends, or an extended network of friends to share their feeling on a particular subject, potentially without really understanding what they are "sharing" on Facebook or "retweeting" on Twitter. "This

[82] Geoff Hughes, "Social Media Guy's Blog: Social Media 'Crowd Swarming:' a Natural Impulse," Nudge Social Media, December 2, 2009, accessed November 10, 2014, https://hyuz.wordpress.com/category/technology/, paragraph 2.

phenomenon is the digital version of a stampede of people moved by hysteria".[83] Crowd swarming may start out in the arena of hysteria, but as those sharing the message strictly under the "bandwagon effect" fall off the thread, others with stronger beliefs remain and attempt to gather additional support. This effect has the potential to spill over to the physical realm in the form of battleswarming or social swarming.

The number of individuals on Facebook during the January uprising in Egypt was less than 100,000 people. There are no exact numbers as to how many people each of the people on social media interacted with and convinced to participate, but if each of the people that signed up for the protest convinced ten other people to join, the number of active protesters could grow to one million in a very short period of time. It is difficult to determine the exact number of protestors, in relation to internet users. On average, eight people shared each internet account in Egypt at the time, so the actual number of participants interacting on social media was most likely much higher than the actual number of 100,000 Facebook users would suggest.[84] The ability to move from digital swarming with online activism to physical activism became apparent during the Egyptian protests and one could expect similar results in future environments. These examples showing why and how complex adaptive systems in nature employ characteristics of flocking and schooling as an element of self-organization demonstrate how and why crowds of people, either digitally or physically, unknowingly employ the same characteristics to provide safety for the group and enable the group to move towards a common goal. Flocking and schooling helps a group move towards a common objective, but it would not be as successful without some way to distribute tasks inside of the group while moving towards that objective.

[83] Hughes, paragraph 6.

[84] Gunning and Baron, 292.

Task Allocation Alters to React to Changing Conditions

The third characteristic of self-organization is task allocation among the group. Deborah M. Gordon, author of *Ant Encounters: Interaction Networks and Colony Behavior*, described task allocation as "the process that adjusts the number of ants performing each task according to the current situation, both in the world around the colony and inside the colony." [85] Task allocation operates without central or hierarchical control. Using ant colonies as a comparison, the most important tasks include nest maintenance, patrolling, foraging, and refuse sorting. Individual ants are adaptive and may conduct a variety of tasks, depending on the environment. The numbers of workers and interaction rates influence the number of workers pursuing each kind of task. Larger colonies are more deterministic and consistent in task allocation than smaller colonies because more ants mean more distributed data. The theory states that larger colonies can get more samples and therefore, better statistics, based on interaction rates.[86]

Task allocation may occur in a similar fashion within a social media-driven mass mobilization. Through applications such as Facebook, people can quickly send out location and time of a demonstration to an established group. During a demonstration, or even while moving to a location for a demonstration, individuals can send locations of best routes of travel via Facebook, or more likely using Twitter or a similar application. Communication via Twitter may be more difficult for governments to monitor, because it can be sent to an identified group of people; Facebook posts often notify anyone following the "page". In January 2011, the Egyptian government slowly recognized communication occurring among the protestors and shut down mobile phones, internet networks, and blocked Twitter. One journalist quoted a protester in his news blog declaring, "twitter was even more instrumental in passing on crucial information,

[85] Deborah M. Gordon, *Ant Encounters Interaction Networks and Colony Behavior* (New Jersey: Princeton University Press, 2010), 24.

[86] Gordon, *Ant Encounters Interaction Networks and Colony Behavior*, 83-89.

ranging from ‘practical information on the protests, such as weaknesses in the protesters’ lines and instructions on how to deal with a tear gas attack, to defiant messages of commitment to the cause and even notices that they were about to get arrested.”[87] This not only helped in task allocation, but also simultaneously gave instruction on how to do the task. Digital applications may help structure some type of task allocation leading up to a planned activity, but during the physical action, task allocation works in a similar fashion to the ant colony—without hierarchical control. The number of other demonstrators individuals see engaged in tasks, such as filming video with electronic devices, uploading to the internet, and interacting with security personnel help determine the number of demonstrators conducting each type of task inside the group. Each of the things that the crowd deems necessary, based on the intent of the gathering, is determined without a central figure dictating individual action.

Decision-Making through Quorum Sensing

Decision-making in social insect colonies occurs in a distributed manner, making use of a group or collective intelligence, rather than individual intelligence. In the late 1990s, scientists still believed that the queen insect in colonies contained centralized information, issued orders, and directed the colony as a monarch would. Multiple research proved that this is not the case. While the queen may regulate some of the colonies’ activities, rarely does the queen issue orders and is better characterized as an oversized individual organism that lays eggs for the colony.[88] Decision-making in a group relies on coordination between individuals in order for the group to decide on a solution to a problem, whether it is a decision on where to build a nest, or what

[87] Siddique, Owen, and Gabbatt, line 98.

[88] Eric Bonabeau, “Social Insect Colonies as Complex Adaptive Systems,” *Ecosystems* 1, no. 5 (1998): 437-443, accessed November 14, 2014, http://www.santafe.edu/media/working papers/98-07-067.pdf; Thomas D. Seeley, “When is Self-Organization Used in Biological Systems?” *The Biological Bulletin* 202, no. 3 (June 2002): 314-318, accessed November 14, 2014, http://www.biolbull.org/content/202/3/314.long.

direction to go to forage. These problems are difficult cognitive challenges for a group of insects, but using a type of quorum sensing mechanism, a colony of bees, is able to determine when a decision has been reached.[89] Getting a unanimous agreement in a colony of bees—to the same degree as in the US Congress—is almost impossible, so the bees rely on a method that relies on a relatively small portion of the colony to make the decision. Scouts find potential locations, and then share the location with other scouts. When enough scouts convince their fellow scouts that a location is best, or at least better than another location, they begin building a consensus, which allows for a decision. In this manner, the colony can make a decision in a relatively short time, without sacrificing the quality of the decision.[90] Similar phenomenon can occur in large groups of people.

Decision-making can occur in crowds of people without direct tasking. An experiment conducted in Germany showed how few individuals with the correct information were able to influence a large crowd of people. Researchers gave directions to only ten people in a crowd of 200. "But after a relatively short period of sorting out, the informed individuals were able to lead the others to the designated target. . . . What was noteworthy about the experiment was how few

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[89] Thomas D. Seeley, P. Kirk Visscher, and Kevin M. Passino, "Group Decision Making in Honey Bee Swarms," *American Scientist* 94 (May-June 2006): 222-223, accessed December 17, 2014, http://www2.ece.ohio-state.edu/~passino/PapersToPost/GrpDecMakHoneyBees-AmSci.pdf.

[90] Kevin M. Passino and Thomas D. Seeley, "Modeling and Analysis of Nest-Site Selection by Honeybee Swarms: the Speed and Accuracy Trade-Off," *Behavioral Ecology and Sociobiology* 59 (2006): 429, accessed December 19, 2014, http://www2.ece.ohio-state.edu/~passino/PapersToPost/PassinoSeeleyNSS-BES.pdf; Nigel R. Franks, Anna Dornhaus, Jon P. Fitzsimmons, and Martin Stevens, "Speed Verses Accuracy in Collective Decision Making," *Proceedings: Biological Sciences* 270, no. 1532 (December 2003): 2457-2459, accessed December 19, 2014, http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0CCoQFjAB&url=http%3A%2F%2Fwww.researchgate.net%2Fprofile%2FAnna_Dornhaus%2Fpublication%2F8967292_Speed_versus_accuracy_in_collective_decision_making%2Flinks%2F0912f50e5ece0f2319000000.pdf&ei=KGgjVaTEHImBygS0wIGAAg&usg=AFQjCNEHRW6s3TG6GwaUaGOIHvgJA3gVnw&sig2=DMssZF38nLB1GTQR0KzuZg&bvm=bv.89947451,d.aWw.

informed individuals were required: only 5 percent."[91] The quorum sensing mechanism used by colonies of insects may be similar to how large crowds of people make decisions. Crowds that contain an influential individual or individuals with the ability to broadcast to the entire group could have a more organized or hierarchical decision method. In a crowded group in a square or a large online group, just a few informed individuals may convince enough individuals to reach a relatively informed decision quickly.

Messaging from a few perceived informed individuals coupled with events broadcasted through social and mainstream media serve to increase the impetus to join demonstrations or riots. During the beginning of the uprising in Egypt, the successful overthrow of the Tunisian government served to reinforce the messaging that relatively few individuals in Egypt were broadcasting. "The fact that earlier in January a reported 250 activists were able to influence the protest pattern of 4,000 protesters in a protest against the bombing in Alexandria underlines how influential a small, well-coordinated cadre of activists can be."[92] The activists were busy on social media, and when the government shut down the internet, messaging and activity spread by those outside of the social media community. Traditional ways of spreading information in communities, such as through taxi drivers, helped to increase the size of the audience receiving the message, and the crowds made informed decisions as a result.

Summary of Characteristics of Self-Organization

The Swarm is not always smart. Since there is no formal command structure in swarms, or in mass mobilization, the systems can work individually to attain a higher goal, but this does not always work in the long term, particularly when facing an adversary that has the ability to think strategically. Since each individual actor is following simple rules, there is a possibility that

[91] Miller, 213.

[92] Gunning and Baron, 292.

when an outside force exerts itself into the network, that the colony, or crowd, will be unable to cope. For example, T.C. Schneirla, a biologist, stumbled upon a group of hundreds of army ants that, by following the basic rules in their system, ended up caught in an endless rotational trek. Instead of crossing a clearing, something interrupted their path, and they became stuck walking in a counterclockwise circle. They did this until ultimately following over and dying from exhaustion.[93] There is a potential, when a higher command is not present, that they groups can follow a self-destructive pattern, such as the stampede in Accra, Ghana in 2001 where around 130 people were crushed to death at their own hands while trying to escape from an overcrowded stadium.[94] This shows that complex systems may not always follow the most efficient path towards their goal and the possibility exists to insert a specific action at the right time that may destabilize the group effort.[95] Limitations of self-organization offer some possible ways a planner may exploit the system.

Even without the ability for strategic planning, social animals and insects exhibit a surprising capability to organize within their colonies, without central control. Mass mobilizations display the same capability. Without a defined command structure, large groups of people using social media can work towards a common goal using the same type of characteristics of self-mobilization. Groups form online, taking advantage of the benefits of

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[93] T.C. Schneirla, "A Unique Case of Circular Milling in Ants, Considered in Relation to Trail Following and the General Problem of Orientation," *American Museum of Natural History*, no. 1253 (April 8, 1944), accessed November 12, 2015, http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.174.1490&rank=1, 6.

[94] Kwaku Sakyi-Addo, "At Least 126 Die in Ghana Football Stadium Stampede," *Guardian*, May 10, 2001, accessed September 2, 2015, http://www.theguardian.com/world/2001/may/11/football.

[95] An example of an organization without strict hierarchical having difficulty achieving an objective includes the Palestinian Liberation Organization (PLO). After Israel exiled Yasser Arafat, Arafat remained in Tunisia. The PLO continued terrorist attacks in Israel that resulted in undermining the negotiations between the PLO and the United States. "Yasser Arafat," *Jewish Virtual Library*, accessed January 17, 2015, http://www.jewishvirtuallibrary.org/jsource/biography/arafat.html.

clustering, in both the digital realm and physical world. They learn to move towards the same objective simultaneously, and allocate tasks, changing tasks when the environment and statistical evidence warrants a change. They make decisions without a leader delegating orders and without waiting for a consensus among the entire group of people. The characteristics of self-organization offer one way to understand how groups of people can organize and rally towards a goal without central control. Planners must first understand how a complex adaptive system operates before they can begin to anticipate how that system may act in the future, which will be explored in the next section.

Anticipate Using Characteristics of Emergence in a Complex Adaptive System

The idea of complexity can lead people to believe that complex adaptive systems contain so many variables and are so unpredictable that there is no way to anticipate potential actions by the system. On the other end of the spectrum, some might believe that breaking down the system into the smallest components will help to predict the behavior of that system. There may be a place in the middle of these two extremes where a planner can find ways to anticipate actions along a range of potential options. Operational thinking is a way to overcome some of the unpredictable nature of individual actors or actions in the system. Gharajedaghi observed, "it is important to note that although multi-loop nonlinear feedback systems exhibit chaotic behavior, there is an order in this chaos. Such systems seem to be attracted to a particular pattern of behavior. By operational thinking we can discover this pattern."[96] One way to identify system trends is through the manifestation of emergence within a system. Emergent behaviors exhibit themselves in four ways that include: (1) information processing, (2) hierarchical organizations, (3) dynamics, and (4) evolution and learning. Since complex adaptive systems produce emergent behaviors, planners may be able to anticipate how mass mobilization and social media interaction

[96] Gharajedaghi, 9.

may cause emergent behavior. Axelrod and Cohen noted, "for us, 'complexity' does not simply denote 'many moving parts.' Instead, complexity indicates that the system consists of parts which interact in ways that heavily influence the probabilities of later events."[97]

Information Processing through Local Sampling and Statistics

Information processing in a complex system works differently than in computer science, a standard business, or a military organization. In a military unit, for example, specific people receive what the organization assesses as critical information so the decision makers can have the most relevant data to make a decision. In contrast, a self-organizing system, especially in biology, gains information as a whole from the environment and its own state. The way in which the system gains information is a good method for exploring how the system operates, interacts with its environment, and is able to makes decisions. Systems in nature tend to resemble each other in how they gather information. This is why information processing is a good starting point to determine how a system may react in an environment and may give planners a way to begin anticipating reactions by the system.[98]

Individual components do not gain and process information and then make decisions individually in a self-organized system.[99] In biology, methods of gaining information come through analog patterns, distributed in time and space and over the system's components, so the information may not be easily recognizable, especially not in a snapshot of the situation. Another way the system presents information is through patterns of individuals and their products, such as

[97] Axelrod and Cohen, 15.

[98] Murray Gell-Mann, *The Quark and the Jaguar: Adventures in the Simple and the Complex* (New York: W. H. Freeman and Company, 1994), 23-26.

[99] Melanie Mitchell, "Introduction to Complexity" (video of Santa Fe Institute lecture 7.5 Information Processing, Fall 2014), *Complexity Explorer*, accessed November 3, 2014, http://www.complexityexplorer.org.

ant trails that represent information about food or locations of the colony. Finally, the system gathers information via local statistical sampling from these patterns. Again, in ant colonies, no one ant gathers all of the information relevant to the colony. Rather, each ant gathers statistics from local sampling and pheromone, trails, and through the number of local interactions, to gather relevant information.[100]

Once the information is gathered, the system must process it. Biological systems do this in a decentralized manner that involves some level of randomness. A continuous interplay of positive and negative feedback assist in the processing of information. If the local sampling of the level of pheromone by an individual ant results in a recognition of a decreasing level of pheromone, the ant can use this negative feedback, just as it would use positive feedback, represented by an increasing level of pheromone. Randomness is everywhere in the system, but unlike individual people who may be confused by randomness, the system can use this to its advantage. Scientists are increasingly discovering that the way biological organisms receive and process information is better in a complex environment, than the binary language of computation.[101] Natural selection for adaptive functions within the ant colony gives meaning to the processed information, as the colony will increasingly benefit from the information received by the distributed actions. Businesses have used biological models as a foundation to develop efficiencies in their business. Businesses engaged in telecommunications routing have used ant foraging models to help make their telecommunications routing more efficient. Companies have used firefly synchronization to develop models for distributed synchronization, and transportation companies have used models of evolution within a species to inspire genetic algorithms to

[100] Melanie Mitchell, "Introduction to Complexity" (video of Santa Fe Institute lecture 7.5 Information Processing, Fall 2014), *Complexity Explorer*, accessed November 3, 2014, http://www.complexityexplorer.org.

[101] Ibid.

improve delivery routing.[102] Patterns can emerge from the way a system involving mass mobilization and social media receives, processes, and gives meaning to information.

Information processing in present day mobilization is very different from in the past, before the advent of social media. Mainstream media sources enjoyed a primarily one-way flow of information from media networks to the people. The difference now lies in the ability for two-way communication. Much like in an ant colony where each ant, in interacting with another ant, learns something about its environment and at the same time, the other ant is simultaneously communicating and learning, new media offers multiple platforms and networks for two-way communication. Dolman commented on the change in the nature of information processing inside of social systems that now allow for voices that did not have a chance to be heard in the past, to now be heard and reacted to.

> Indeed, social systems tend toward positive feedback mechanisms, which add additional input to already moving or correcting behavior. This allows for extremely disruptive and violent change within the system. If negative feedback is the means of balancing, positive feedback creates bandwagoning behavior. An example is the rumor, or the e-mail legend, which starts as speculation and can spread through a social system until it is more than a confirmed fact, it is a phenomenon."[103]

The potential for videos to 'go viral' and people to push information to networks has increased dramatically. One of the demonstrators in the Egyptian, desiring to increase the speed of information flow, reflected on his decision to choose a Facebook page, rather than a Facebook group:

> As an experienced Internet user, I knew that a Facebook page was much more effective in spreading information than a Facebook group. As soon as someone "likes" a page, Facebook considers the person and the page to be "friends." So if the "admin" of the page writes a post on the "wall," it appears on the walls of the page's fans. This is how ideas

[102] Melanie Mitchell, "Introduction to Complexity" (video of Santa Fe Institute lecture 7.5 Information Processing, Fall 2014), *Complexity Explorer*, accessed November 3, 2014, http://www.complexityexplorer.org; Richard Jones, *Garbage Collection: Algorithms for Automatic Dynamic Memory Management* (West Sussex, England: John Wiley & Sons Ltd.,) 1996, 19-24.

[103] Dollman, *Pure Strategy*, 123.

> spread like viruses. . . . In the case of groups, however, users have to access the group to remain updated; no information is pushed out to them.[104]

There was a time that a regime could push information to an audience that stated, for example, that they treat all protestors with respect. A protestor using Twitter before the government blocked it, notified audiences around the world that security forces punished him for nothing and he had been "beaten a lot."[105] The protestor had the ability to link to pictures or video where he could have provided physical evidence of the beating, if he chose. One example was the case of the Facebook page of Khaled Said. One of the other protesters remembered the impact of the pictures of Khaled and said, "If we had not seen it, we would not have cared."[106] The ability for a regime to push a narrative without people pushing back is fading into the past. Individual empowerment, supported by a cell phone or computer and data or internet connection, has the ability to trump a multi-million dollar media company. By simply uploading pictures or a video, an individual can push a narrative that has the ability to create an information cascade that is difficult to slow.

Hierarchical Organizations Promote Survival

One of the common principles of complex adaptive systems identified earlier was that systems operate without a central control. However, a type of hierarchical organization may emerge from the system. This does not suggest that a familiar pyramid or dictator-type control structure would emerge. Examples of this emergent behavior exist in nature, from biological organism and cells, to organs in a body, to a colony, or even to society[107]. The need to identify

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[104] Gunning and Baron, 289.

[105] Siddique, Owen, and Gabbatt, line 101.

[106] Gunning and Baron, 290.

[107] Melanie Mitchell, "Introduction to Complexity" (video of Santa Fe Institute lecture 1.3 Properties Common to Complex Systems, Fall 2014), *Complexity Explorer*, accessed November 3, 2014, http://www.complexityexplorer.org.

this type of organization was present in the core principles of general systems theory, developed by Ludwig von Bertalanffy, an Australian-born biologist, in the 1950s. "A scientific theory of organization is required, to account for wholeness, growth, differentiation, hierarchical order, dominance, control and competition."[108] Simple agents following simple rules will sometimes not react appropriately to an external action to the system. Planning for future events can be almost nonexistent in self-organized groups, but hierarchical structures developed as emergent properties help to make complex systems more robust.

The emergence of a hierarchical organization can be the change in a system that enables or promotes survival in a fluctuating environment.[109] In some cases, a system may directly benefit from harm when a hierarchical structure develops or evolves in reaction to the threat.[110] A variation of a hierarchical system is characterized as a "heterarchy", where there is no higher or lower level, just different levels that are different qualitatively, without a formal tiered structure. These systems include communication that can flow in any direction from any agent and tend to move a system towards chaos, rather than a utopia where every element communicates to each other on an equal basis. Instead of perfect communication, heterarchies often result in overwhelming information and connections that lead to the system's demise. These systems lie in

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[108] Alex Ryan, "*What is a Systems Approach?"* Cornell University Library, accessed March 9, 2015, http://www.arxiv.org/pdf/0809.1698.pdf, 9.

[109] Ryan, 12. Ryan elaborates further on the evolutionary process of hierarchical emergence in systems saying, "Given that a hierarchy of building blocks can be assembled orders of magnitude faster than a non-hierarchical assembly process, among complex forms, hierarchies are the ones that have the time to evolve."

[110] Nassim Nicholas Taleb, *Antifragile: Things that Gain from Disorder* (New York: Random House, Inc., 2012), 85. "When an organism directly benefits from harm; with evolution, something hierarchically superior to that organism benefits from the damage."

contrast to those that develop hierarchical structures that increase the system's hardiness to a fluctuating environment.[111]

In the example of ants discussed previously, the colony may develop an emergent hierarchical system. Ants in a colony conduct numerous tasks, and communication between the different groups conducting those tasks can cause a change in the numbers of ants performing other tasks, based on unexpected changes in the environment, such as a storm or external threat. The division of labor can shift within the hierarchical system based on what the colony collectively "believes" is more important at the time. A storm creating flood conditions for the ant colony could shift the division of labor from collecting and distributing food to care for the nest or eggs. Similar hierarchical properties may emerge in mass mobilization when coupled with social media. Where changes would have taken longer to reverberate through the system in the past, individuals communicating via social media to respond to changes in the security environment can immediately inform the group following them on Twitter, via a Facebook page, or other application. For example, individuals filling the role of reconnaissance can shift roles immediately in response to changes in the environment. A system where all of these actors communicate almost simultaneously—such as the heterachy example listed in the previous paragraph—would most likely lead to chaos where large shifts of tasks and roles would occur on a constant basis and keep the system in a continuous flux.

Malcolm Gladwell, journalist and author of *The Tipping Point*, stated that there are generally three types of people: mavens, salespeople and connectors. Although Gladwell has offered criticism for those attributing success in recent uprisings to social media, the three types of people he identified have filled their respective roles in the mobilization efforts and can form a

[111] Jad Bitar, "Towards an Understanding of Elusive Organizational Phenomena: Organizations as Complex Adaptive Systems" (thesis, HEC Montreal, 2006), accessed December 3, 2014, http://webcache.googleusercontent.com/search?q=cache:f-8vxQjhuPYJ:neumann.hec.ca/chairemsi/pdfcahiersrech/06_27_02.pdf+&cd=11&hl=en&ct=clnk&gl=us, 14.

type of hierarchical structure within the system. Mavens have a lot of information that they use to connect people to the marketplace, or in this instance, with the social or political movement.[112] Salespeople are good at providing the actual message.[113] Connectors are often charismatic and become the social glue that spreads the message, linking others with the world.[114] It is possible to pick these people out as they operate in the environment of social media. Those who use Facebook can probably think of those people that fall into each of the three categories. Mavens hold a lot of information about politics, grievances, and social events, and tend to share them. They share them with not only those who ask, but often share the information unprompted. Salespeople often comment on posts that mavens might share or use mediums such as blogs to give their advice. The salesperson task may be more difficult in the digital world, since salespeople tend to have an indefinable trait that goes beyond the message when communicating in person. Others cannot help suggesting friends to others and open up friends and acquaintances to new social circles: These people are connectors. None of these groups formally takes orders from the others, but direction and purpose can emerge from the formation of this type of hierarchy within a group.

Dynamics Determine How the System Changes its Patterns

The third way planners can anticipate a system through emergent behavior is by identifying dynamics in the system. The field of dynamics is a very general field and includes areas such as fluid dynamics, climate dynamics, financial dynamics, crowd dynamics, and population dynamics. The way complex adaptive systems process information and develop

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[112] Malcolm Gladwell, *The Tipping Point: How Little Things Can Make a Big Difference* (Boston: Little, Brown, 2010), 60-63.

[113] Ibid., 70-73.

[114] Ibid., 38-46.

hierarchical structures necessarily infer that the system will change. Dynamics determine how the system changes its patterns in space over time and is critical to anticipating how the changes in patterns will change the system; dynamics theory provides a vocabulary for describing the emergent complex behavior.[115]

Dynamics exist in ant colonies and other social insects. For example, the arboreal turtle ant develops multiple foraging trails from numerous nest sites to sustain colonies. Studies show that a distinct group of foragers follows each trail, which makes the foraging effort as a whole, more resilient. Instead of disrupting the colony foraging effort during a block of one of the trails, only the affected group desists gathering food while the foragers become scouts, recruit other ants to follow them when they find another trail, which increases the pheromone level and eventually pulls the group towards a new path. The colony can also change, based on the amount of time the groups of ants require to find a new trail. The decrease of foraging interactions at the nest can change the colonies behavior. Some ants dedicated to other tasks may switch to reconnaissance, and when they find a new food source, additional ants will pick up the trail to begin a new foraging effort.[116] Identifying the dynamic nature of the colony to understand how the system reacts to changes in the environment is essential to anticipating how that system will react in the future.

Mass mobilization and social media converge to provide protesters the ability to use varying means to spread their message. Dynamics in the system allow the people and groups interested in contentious politics, to change and react to an unpredictable environment. The Egyptian government shut down of the internet and blocking of social media on January 27, 2011

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[115] Melanie Mitchell, "Introduction to Complexity" (video of Santa Fe Institute lecture 1.3 Properties Common to Complex Systems, Fall 2014), *Complexity Explorer*, accessed November 3, 2014, http://www.complexityexplorer.org.

[116] Deborah M. Gordon, "The Dynamics of Foraging Trails in the Tropical Arboreal Ant Cephalotes goniodontus," *PLoS ONE* 7, no. 11 (November 2012), accessed March 12, 2015, http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0050472.

could mean that, since the protests continued to grow, that social media was unimportant to the movement as a whole. The overwhelming amount of data gathered for this paper; however, show how social media played a facilitating role in the uprising. Instead of ending the demonstration, the activity on the streets and online activity prior to the shutdown allowed the popular mobilization to continue. Since demonstrators planned events prior to the internet outage, protestors had already signed up to be a part of future protests, and the activities continued as planned. Not only did the activity continue as planned, it grew. One explanation is that since people had lost their connection to media sources outside of the state-run media, they moved out to the streets. This effectively bridged the gap between the communities active online, with the communities not online. Shutting down the internet, in part, added to the movement. As one of the demonstrators noted:

> Pre-revolution, Facebook played a huge role in mobilizing the middle class [especially after the death of Khaled Said]. But there is a huge gap between this class and real people. These two communities met when the Internet was shut down. That was a huge government mistake. If you are an Internet activist, you click 'like' and you feel great. But without the Internet, you go out. Then you feel great on the street, and you build momentum. It helped the revolution.[117]

Another activist, Saif, stated:

> The virtual networks created over social networks like Facebook and Twitter moved into the real world for the first time. Once people turned to the streets, the process became organic with demonstrators meeting acquaintances and joining groups during their march to Tahrir Square. Word of mouth became the main tool for planning the next steps, confirmed Saif. Demonstrators at Tahrir agreed before they left to convene the next day at 3PM. As they walked home, they spread the word on the street.[118]

After the blackout ended, the protestors resumed using social media as a more efficient way to spread information. Even during the blackout, though, the system found a way to cope with the problem. "Using landlines, international satellite phones, dial-up modems, FTP (file transfer protocol) accounts and 'Speak to Tweet', activists succeeded in bypassing the blackout and

[117] Gunning and Baron, 286.

[118] Ibid., 286.

keeping the world's media informed of unfolding events in Egypt."[119] The system continued to change to respond to developments. Without a central figure to guide the changes, the system developed ways to cope and began to evolve with the environment.

Systems Adapt through Evolution and Learning

The last emergent property that planners should consider when analyzing a situation involving modern day mass mobilization is evolution and learning. Adaptation or learning is essential for a system to sustain and grow in an environment. It is crucial to understand that there is no real separation between a system and its environment; rather, a complex system adapts to its changing environment in a co-evolutionary manner. With this in mind, it is often essential that a system improves to cope with changes in the environment in order to survive.[120]

The immune system provides a good example of adaption within its environment. Just like previous examples involving ant colonies, cells in the immune system communicate using chemical signals. They work towards a common goal without central control and develop emergent capabilities when new threats enter into their environment. They are able to gather information about their environment, process it, and conduct coordinated attacks against threats in the body. The number of immune cells will increase in numbers to respond to specific threats and adapt in future environments, decreasing to sustainable levels when the threat is no longer present.[121] ADRP 3-0 recognizes the potential for a learning enemy, which signals the need to

[119] Gunning and Baron, 286.

[120] Melanie Mitchell, "Introduction to Complexity" (video of Santa Fe Institute lecture 7.5 Information Processing, Fall 2014), *Complexity Explorer*, accessed November 3, 2014, http://www.complexityexplorer.org.

[121] Melanie Mitchell, "Introduction to Complexity" (video of Santa Fe Institute lecture 1.2 Introduction to the Study of Complexity, Fall 2014), *Complexity Explorer*, accessed November 3, 2014, http://www.complexityexplorer.org.

continuously evaluate threats in the operational environment, which may necessitate small changes to the plan, or a complete reframing of the enemy and environment.

> In addition, an operational environment continually evolves. This evolution results from humans interacting within an operational environment as well as from their ability to learn and adapt. As people take action in an operational environment, they change that environment. Other variables may also change an operational environment. Some changes are anticipated while others are not. Some changes are immediate and apparent while other changes evolve over time or are extremely difficult to detect.[122]

Applying the concept of evolution and learning with the previous emergent characteristic of dynamics are critical components to anticipating actions in an evolving enemy in a changing environment.

During the Egyptian uprising, protesters and the government used media networks to spread competing narratives. Autocracies such as Iran brutally suppress uprisings, making it more costly to get involved with the protests. International opinion does matter to regimes such as in Iran, but it matters more in a country tied to the international community through tourism and trade with regional and international partners, like Egypt.[123] Protesters and media companies such as Al Jazeer decreased the focus on violence, perhaps in an attempt to draw more protesters. At the same time the Egyptian state-run media, Al Ahram, initially ran violent stories to raise the perceived cost of participation. They also minimized coverage of the successful mobilization in an attempt to lower the perceived benefit of participation.[124] To combat the state-run media, the

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[122] Army Doctrine Reference Publication (ADRP) 3-0, *Unified Land Operations* (Washington, DC: Government Printing Office, 2012), 1-2.

[123] "Middle East, North Africa, Pakistan and Afghanistan: Turning the Corner?" *International Monetary Fund*, May 2014, accessed January 2, 2015, https://www.imf.org/external/pubs/ft/reo/2014/mcd/eng/pdf/menacca0514.pdf, 8-10.

[124] Ahmed Magdy Youssef, "A Critical Analysis on Media Coverage of the Egyptian Revolution: The Case of Al-Masry Al-Youm, the Telegraph and the Washington Post," MA thesis, Orebro University, 2012, accessed March 7, 2015, www.diva-portal.org/smash/get/diva2:540808/FULLTEXT01.pdf, 12, 19, 24, 27, 43; Hend Selim, "The Coverage of Egypt's Revolution in the Egyptian, American and Israeli Newspapers," Reuters Institute for the Study of Journalism, 36, 37, 52, 71, 116.

organizations desiring regime change learned to spread information on two different levels; they spread information to Egyptians that emphasized reduced risk to protestors, while emphasizing violent actions by the government on the international stage. According to Marc Lynch, professor of political science and international affairs at George Washington University, “the new media may also increase the prospect of collective action by raising the costs to authoritarian regimes of repression, especially early on, by documenting atrocities and increasing international attention.”[125] The organizations learned and adapted to their environment, and developed new patterns of behavior designed to increase the system’s resiliency.

Summary of Emergence in Complex Adaptive Systems

Systems that produce patterns from uncoordinated local action in the way they process information, produce types of hierarchical organizations, develop dynamics, and evolve—provide ways to anticipate actions of that system. "What appears as chaos at one level,” Dolman identified, “has order and meaning at another. This is what makes the emergence of order more than a trivial coincidence."[126] In describing defeat mechanisms in ADPR 3-0, the manual states, “temporally defeating the enemy anticipates enemy reactions and counters them before they can become effective.”[127] Planners identifying simple patterns that emerge in the system can enable those planners to anticipate future actions of that system to prevent unanticipated events from disrupting the mission.

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[125] Marc Lynch, “After Egypt: The Limits and Promise of Online Challenges to the Authoritarian Arab State,” *Perspectives on Politics* 9, no. 2 (June 2011): 305, accessed December 10, 2014, http://www.marclynch.com/wp-content/uploads/2011/06/download-Lynch-article.pdf.

[126] Dolman, 108.

[127] ADRP 3-0, 2-9.

Exploit the Common Properties of Networks

Characteristics of self-organization in a complex adaptive system can help a planner understand a potential threat, while characteristics of emergence can help in anticipating that threat. The study of complex adaptive systems can reveal ways of exploiting those systems through the science of networks. As Axelrod and Cohen stated:

> The phrase [harnessing complexity] means deliberately changing the structure of a system in order to increase some measure of performance and to do so by exploiting an understanding that the system itself is complex. Putting it more simply, the idea is to use our knowledge of complexity to do better. To harness complexity typically means living with it, rather than trying to ignore or eliminate it.[128]

Eliminating a threat is habitually the first and easiest solution that the military offers to solve problems in the operating environment. It is usually more difficult to find ways to exploit the problem, but when interacting with a complex adaptive system, the best long-term results may come from working with the problem, rather than eradicating it.

Protestors using social media have complicated government efforts to limit the effects of mass mobilization, but the networks formed through the combination of social media and mass mobilization may actually provide some insight into ways of exploiting the efforts. The science of networks through the lens of complex system science may provide the appropriate lens. By identifying some common properties of networks, planners may be able to find ways of exploiting those networks. Five of the properties that the Santa Fe Institute proposed include: (1) small world property, (2) long-tailed degree distribution, (3) clustering and community structure, (4) vulnerability to targeted hub attacks, and (5) vulnerability to cascading failures.[129] There may be additional properties discovered by continued research, but this paper will focus on the five common properties listed above to determine which network properties the US Army can

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[128] Axelrod and Cohen, 9.

[129] Melanie Mitchell, "Introduction to Complexity" (video of Santa Fe Institute lecture 9.1 Introduction, Fall 2014), *Complexity Explorer*, accessed November 3, 2014, http://www.complexityexplorer.org.

potentially exploit in the operational environment. This section will describe the main components of networks, followed by network terminology, and finally discuss robustness to random node failure found in most networks before analyzing the five properties for exploitation. The suggested ways of exploitation within networks will remain conceptual in this section and does not infer that the Army can exploit each network in the same way. Different types of governments, society structures, religious preferences, and a multitude of other characteristics makes concrete answers impossible. Suggestions for exploitation are meant to spur additional ideas on ways to exploit networks instead of simply trying to eliminate them.

Networks are found everywhere in life. Networks include neural networks, the food web in nature, the metabolic network, airline routes, the US power grid, the bank network, the World Wide Web, and social networks. Networks contain two main components: nodes and links. The nodes refer to the individual connection points in the network. In a home internet network, the nodes could refer to computers or printers inside of the network. Links are the connections between the nodes that can be directed or undirected. Communication in an undirected link goes both ways, while communication in a directed link is one directional. Facebook provides a social media example of links, where "friendship" links are undirected, in that someone cannot be friends with someone else, without that person being friends with them. Conversely, Twitter contains directed links where some people follow other people, without a reciprocated action. In directed networks, in-degree refers to the number of links coming into the node and out-degree refers to the number of links going out from the node. The degree of a node is determined by the number of links going into that node.

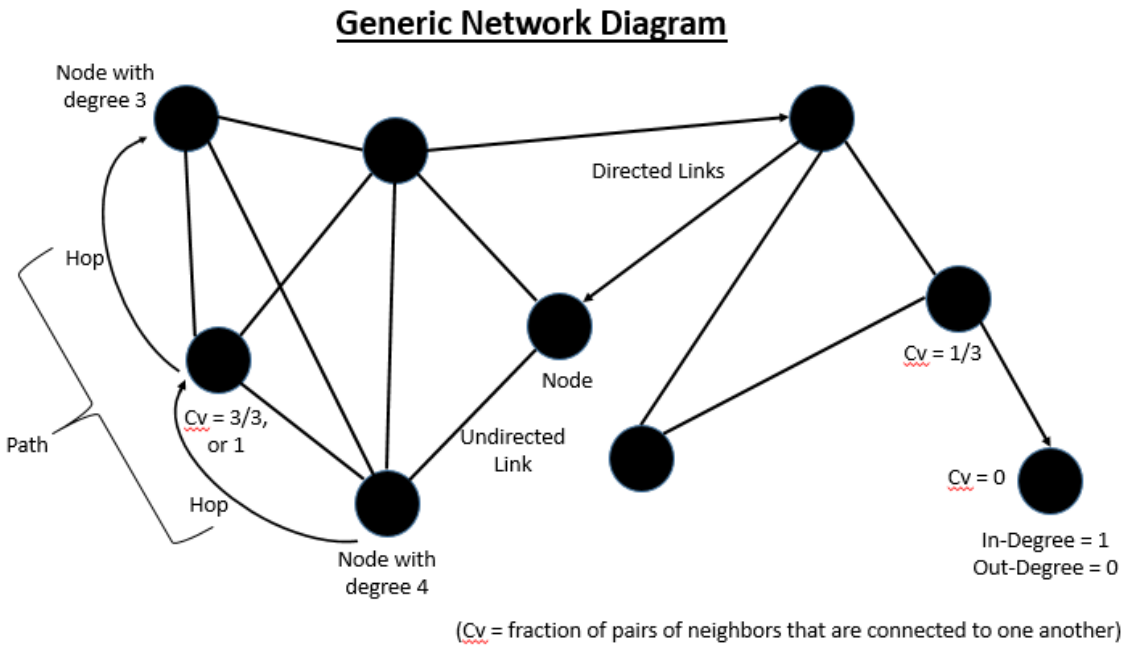

Figure 2. Generic Network Diagram

Source: Created by author, using data from Melanie Mitchell, "Introduction to Complexity" (video of Santa Fe Institute lecture 9.2 Network Terminology, Fall 2014), *Complexity Explorer*, accessed November 3, 2014, http://www.complexityexplorer.org.

Hops, paths, distances, clusters, and hubs are terms that help describe the interactions within a network. A hop indicates when one node directly connects with another, and the sequence of hops within the network indicates a path within the network. Clustering in a network is the fraction of pairs of neighbors connected to each other. In the Facebook example, people can view a friend's profile and determine, out of the friends that that person has, which ones are mutual friends. These mutual friends would indicate the cluster of friends or the extent that friends are also friends of each other. The closest dictionary definition of a hub in reference to a network is "a center around which other things revolve or from which they radiate; a focus of activity, authority, commerce, transportation, etc."[130] The term hub is common in the airline networks, where hub is a node with multiple in-degree and out-degree links, which indicates a

[130] "Hub," Dictionary.com, accessed December 20, 2014, http://www.dictionary.reference.com/browse/hub?s=t.

higher percentage of links, compared to the other nodes in the network. The varying degree of distribution and frequency inside of the networks define the variations or types of networks. Graphing the degree of distribution in the network by putting the numbers of degrees on one axis and the frequency of the degrees on the other axis, helps to determine the type of network. In this way, one can categorize the three different types of networks, which include regular, random, and small world. Most types of real world networks fall under the small world type of network.

Networks display a robustness or resilience to random node failure. Since most nodes inside of a network have a low degree, or low connection to other nodes, individual node failures have little effect on the network as a whole. In the internet network example, internet servers either go down or maintenance workers take them down for servicing every day, but because of the long-tailed structure in the network (covered later), removal or failure of a random node does not generally have a significant impact.[131]

Small World Properties Reveal that Paths in Networks are Shorter than Expected

The first commonality of networks is the small world property. Types of networks include a spectrum with regular networks on one end and completely random networks on the other. Regular networks include a high average distances with high clustering, random networks includes small average distances with low clustering, and a small-world networks have small average distances and high clustering. In a social network, this refers to the path from one person to any other person in the country is actually shorter than expected. Stanley Milgram, a social psychologist, conducted an experiment described as the "Six Degrees of Separation."[132] His

[131] Melanie Mitchell, "Introduction to Complexity" (video of Santa Fe Institute lecture 9.4 Scale Free Networks, Fall 2014), *Complexity Explorer*, accessed November 3, 2014, http://www.complexityexplorer.org.

[132] "Stanley Milgram," Harvard University, accessed January 2, 2015, http://www.isites.harvard.edu/icb/icb.do?keyword=k3007&panel=icb.pagecontent44003%3Ar%241%3Fname%3Dhistoricprofs.html&pageid=icb.page19708&pageContentId=icb.pagecontent44003&view=view.do&viewParam_name=milgram.html.

experiment showed that most real-world networks are small world networks.[133] Two mathematicians named Duncan Watts and Steven Strogatz explored this phenomenon in a popular game referred to as the "six degrees of Kevin Bacon."[134] The challenge involved trying to find the shortest path between any actor and the actor Kevin Bacon, using movie connections. The game assumed that this could always occur within six steps or less.[135] This game actually supported Milgram's conjecture that most real-world networks are small world networks.

The internet network is an example of a small world network. Instead of focusing on the physical structure of the internet network, this property, common to social networks, can provide insight on how planners can exploit a network. Planners can analyze individuals, groups, sheiks, or tribes in a larger society to see which node has the greatest amount of links to other nodes. As Miller observed, influencing these key hubs may provide the best results for the effort. "What's more, these influences spread through the town's social networks like a virus, affecting not only people at one degree of separation, such as a spouse or relative, but also those at two or three degrees."[136] The effort may focus on influencing key individuals or groups to refrain from contentious politics by highlighting the short number of connections between them and their opposition, or even the short distance between them and the security forces directed to provide safety. This is just one example of how a network can be exploited using the small world property.

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[133] Duncan J. Watts and Steven H. Strogatz, "Collective Dynamics of 'Small-World' Networks," *Nature* 393, no. 6684 (June 4, 1998): 440.

[134] Watts and Strogatz, 440.

[135] "Six Degrees of Kevin Bacon," *Wikipedia*, last updated March 24, accessed March 1, 2015, http://en.wikipedia.org/wiki/Six_Degrees_of_Kevin_Bacon.

[136] Miller, 214.

Long-Tailed Degree Distribution Can Give Insight into Social Network

Long-tailed degree distribution, sometimes called fat or heavy-tail distribution, is a common characteristic of small world properties and networks. Most networks contain many nodes with low degree, and few nodes with high degree.[137] The small number of nodes with a high degree is the description of a hub, as mentioned earlier. This type of distribution differs from the normal, or Gaussian distribution shape. The normal shape, or "bell curve," depicts data such as human height or scores on standardized tests."[138] This type of graph is different from graphs with long-tailed degree distribution. Whereas bell curve graphs contain a higher distribution of data in the middle of the curve with lower distributions in the beginning and end, the long tailed distribution contains a larger number of data points in the beginning and reduces to a longer tail of smaller and smaller numbers. The important point is that most common networks in the world exhibit characteristics of the long-tail graph.

Using some of the common characteristics, including the long-tailed degree distribution, Wolfram Alpha, a computational knowledge engine, analyzes social networks using algorithms to produce reports on people or groups on Facebook. The company can give someone insight into their own social network by examining clusters of friends in the person's social network. They can then determine where the friends are located on the globe, define the global reach, and conclude with their popularity amongst those friends. Using algorithms, the company can also track common themes of discussions engaged in on Facebook, explore the structure of the person's friend network, identify who in the network plays special roles, and determine which photographs or videos are most popular in that network.[139] The ability to analyze a network using

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[137] Melanie Mitchell, *Complexity: A Guided Tour* (New York: Oxford University Press, 2009), 235.

[138] Mitchell, *Complexity: A Guided Tour*, 243-244.

[139] "Personal Analytics for Facebook," Wolfram Alpha, accessed March 10, 2015, http://www.wolframalpha.com/facebook/.

algorithms, as Wolfram Alpha is very efficient. The benefit of producing this same type of data on other networks would support the US Army's systems thinking approach and help planners to understand the operating environment and then develop an approach to solving the problems in that environment. The US Army may develop their own method of quickly extracting information from a network, or contract a civilian company to produce reports on specific networks. After analyzing the network, identifying the subsystems within the network that contains long-tailed degree distribution could provide insight on where to effect the system to get the fastest results or where to effect the system for a more gradual approach.

Clustering and Community Structure Indicate How Quickly Information Travels

Clustering and community structure is the third property common to networks. The analysis of clustering and community structure in a network is important, because it may indicative how quickly information will travel inside of the network. It may also indicate how quickly a network will fall apart, if a node with a high clustering coefficient is removed.[140] The extent that friends are also friends of one another indicates the amount of clustering in a social network. A node with only one neighbor has a cluster value of zero, since there are no pairs of neighbors, and a node with each linked node also connected to each other indicates a cluster value of one (1). (See Figure 2).[141]

[140] Melanie Mitchell, "Introduction to Complexity" (video of Santa Fe Institute lecture 9.3 Small World Networks1, Fall 2014), *Complexity Explorer*, accessed November 3, 2014, http://www.complexityexplorer.org.

[141] A node with three neighbors, but with only one linked pair, would have a cluster value of 1/3. Identifying the number of nodes and links in a network provides coefficients of clustering inside of that network. To determine the value of clustering as a whole within the network, one would have to add up each individual clustering coefficient, divide it by the number of total nodes, and derive a relative clustering coefficient for the entire network. For a network where each node connects to every other node, the coefficient for the entire network would be one (1).

One way planners can apply this concept is to the analysis of a government structure or terrorist networks. Networks that contain high clustering could indicate, through analysis of the nodes with low clustering values, which nodes, when removed from the system, will have the least amount of impact to the whole. It could also indicate that systems working well with a low clustering value may not work as well with high clustering values. Identifying the clustering and community structure could provide planers insight into ways to exploit the system. Miller used an example of clustering that, while used to provide protection for individuals, can also cause harm to the system.

> At low densities, people can move freely without a lot of interactions with each other, so that's a kind of gaseous state. When the density becomes higher, people obstruct each other and there are mutual interactions, so one could call this a fluid state….But when density greatly exceeds capacity, even temporarily, the dynamics of a crowd changes, and individuals lose control, both physical and psychological. At extreme densities, individual motion and awareness is replaced by mass motion and response. The crowd loses some of its ability to self-organize and may become an unthinking mass, driven by physics and fear. Instead of breaking down traffic problems through simple rules of thumb and distributing them among countless individuals, as an ant colony does, the crowd flips into a chaotic state driven by self-preservation-more like a swarm of locusts.[142]

The physical example of introducing higher clustering to a system that operates more effectively at a lower clustering value shows how to exploit the system, not only at the physical level, but in a social network example as well. This example also reveals the counterintuitive response that may arise from a complex system. If a planner determines that a specific network operates at the highest efficiency at a certain clustering coefficient, attempting to prevent that network from growing or increasing its clustering coefficient could actually be counterproductive for the Army. In exploring social epidemics in *The Tipping* Point, Gladwell explored the "Rule of 150" and the relation to this rule and effectiveness in "starting an epidemic."[143] "The Rule of 150 says that congregants of a rapidly expanding church, or the members of a social club, or anyone in a group

[142] Miller, 247.

[143] Gladwell, *Tipping Point*, 174, 175.

activity banking on the epidemic spread of shared ideals needs to be particularly cognizant of the perils of bigness. Crossing the 150 line is a small change that can make a big difference."[144] This rule that Gladwell identified does not infer that mass mobilizations cannot handle more than 150 people as protesters, it does; however, indicate that people may have an interesting natural limit that Gladwell refers to as a social channel capacity.[145] Gladwell's research further supports the importance of identifying clustering in networks and by doing so, planners may then be able to use that information to exploit those networks.

Networks May be Vulnerable to Targeted Hub Attacks

The last two common network properties are different from the first four, in that they describe actual vulnerabilities of networks, which is a good place to focus when attempting to exploit a system. As systems evolve and hierarchical or other emergent properties develop, some amount of vulnerability comes with the improvements to the system. Networks show a distinct vulnerability to targeted hub attacks. Risk to the system should be an important factor when considering a targeted hub attack. Hubs inside of a terrorist network can provide a lucrative target for individual removal from the network, but understanding how complex adaptive systems operate indicate that the system will cope with the change and sometimes emerge more resilient from the attack.

The hubs within a network can be the actual physical structure of the internet network, or a hub can involve a critical person or group of people within the movement. Using the example of the different kinds of people that Gladwell referred to in *The Tipping Point*, the "connectors" could be the type of people singled out for constant monitoring, or turning into double agents. Planners can single out people or groups successfully spreading a message using the quantitative

[144] Gladwell, *Tipping Point*, 182, 183.

[145] Ibid., 177.

measuring from the sites they use or operate. Simple techniques such as identifying numbers of followers, "likes," or webpage visits is a good starting point to determine who or which groups may be the most influential. Targeting the physical network hubs for temporary removal from the system may give a reprieve to security forces in a situation, but this should not be a long-term strategy, as the system will find another way to communicate the message via another platform or application. Intelligence officials can monitor the hub to determine ways of countering the narrative. The decision-makers should always balance the short-term benefit of removal of the hub with the potentially worse, long-term consequences. Attempting to influence the actual hub, if it is a person or group, or those connected to the hub, may serve as a better alternative to its removal.

Someone attempting to cause a distributed denial of service attack may target large, highly connected websites. Using the example mentioned earlier of an internet network, a physical or cyber-attack on a hub may cause additional failures within the network for those nodes that link to the targeted hub.[146] Targeting a hub, though, carries risks, as the example from the Egyptian protests illustrates. One example is the leader of Al Qaeda, Ayman al-Zawahiri. He is on the top of the "most wanted" terrorist list, as leader of a sub-system in global terrorism. Consideration should be given to his removal, and how it might affect terrorism overall. Al-Zawahiri declined to accept the inclusion of Al Qaeda under the Islamic State (IS), but a potential successor may not have the same inclination.[147] Some have described the potential combining of IS and Al Qaeda as the most dangerous course of action to civilized society, so it may actually do

[146] Melanie Mitchell, "Introduction to Complexity" (video of Santa Fe Institute lecture 9.4 Scale Free Networks, Fall 2014), *Complexity Explorer*, accessed November 3, 2014, http://www.complexityexplorer.org.

[147] Radwan Mortada, "Al-Qaeda and ISIS: The Renunciation of Abu Bakr al-Baghdadi," *Alakhbar English*, February 4, 2014, accessed March 15, 2015, http://english.al-akhbar.com /node/18519, paragraph 2.

a disservice to civilized society, in this instance, to target that particular hub.[148] In this example, it may be more beneficial to target lower degree hubs that may be responsible for operations, financing, or recruiting as a way to keep the current division between Al Qaeda and IS in place. Some networks may be vulnerable to targeted hub attacks, but a planner will not always know which hubs are vulnerable until interacting with the system. Planners should use caution when they have identified a specific hub for targeting to ensure that they have explored the possible reactions the system.

Cascading Failure May Collapse the Entire Network

The last property is the network's vulnerability to cascading failures. Nodes can cause other nodes to fail, which could lead to something called cascading failure. Networks are resilient to random node failures, as discussed earlier, but sometimes failures of certain nodes will cause a shift of heavier-than-normal loads to other nodes. This act may cause the subsequent nodes to fail and ultimately create a cascading situation where the network experiences an overall failure that may not be recoverable. An example used by the Santa Fe Institute is the electrical blackout in 2003 in the northeast United States and Canada. A downed power line overloaded a power station in Ohio. This power station, or node, transferred its load to another power station, which subsequently failed and transferred its load to another station. This created a domino, or cascading effect that produced mass failures to large portions of the power grid network in the northeastern United States. This incidence caused a change in the way the power grid reacts to failures, helping the system to be more resilient against future node failures. Other examples of cascading failures include bank failures, ecological systems failures, or computer and

[148] William McCants, "How Zawahiri Lost Al Qaeda: Global Jihad Turns on Itself," *Foreign Affairs*, November 19, 2013, accessed March 15, 2015, http://www.foreignaffairs.com/articles/140273/william-mccants/how-zawahiri-lost-al-qaeda, paragraphs 4-6.

communication networks failures.[149] Vulnerability to cascading failures may be of great interest to planners focused on collapsing an entire system.

If a planner can determine that a single node failure may cause other nodes to fail in succession, this could have a dramatic effect on the network and system as a whole. Planners should consider how the entire network or system collapse could affect other systems that it shares undirect or direct links. A planner must take into account the properties of systems discussed earlier to anticipate the potential outcomes and determine if they fall within the scope of desired outcomes acceptable to the commander. Removal or disruption of one node or hub may be sufficient, but multiple hubs may need to be disrupted to cause a cascading failure in the network. Multiple lines of effort may be required to have simultaneous impacts, leading to a chain reaction that would not be recoverable in the short term. To exploit the network for a relative advantage, the planner must be aware, just like in the power grid example, that cascading failure can highlight vulnerabilities in the system that, once repaired, may make future attempts at collapsing the network much more difficult.

Summary of Network Properties

Common properties of networks within complex adaptive systems can give planners a way to exploit networks in the operating environment. Networks formed through the combination of mass mobilization social media provide openings for exploitation through their small world property, long-tailed distribution, and their clustering and community structure. Networks exhibit a robustness to random node failure, but the susceptibilities that include vulnerability to targeted hub attacks and vulnerability to cascading failures may indicate where key weaknesses lie in the system. The US Army can plan to exploit these areas, rather than eliminating them, as a way to

[149] Melanie Mitchell, "Introduction to Complexity" (video of Santa Fe Institute lecture 9.4 Scale Free Networks, Fall 2014), *Complexity Explorer*, accessed November 3, 2014, http://www.complexityexplorer.org.

gain a position of relative advantage with an eye on long-term success in the operating environment.

Conclusion

Intelligence officials believe the future operating environment for the US Army will be in littoral regions or in generally populated areas with asymmetric confrontations and unconventional threats.[150] The US Army needs to continue to adapt to this reality and find new ways to understand current and possible future threats. Populations' intent on social unrest can cause extreme disruption to security services and governments, whether locally or internationally. The case study of the Egyptian uprisings in 2011 reveals how social media enhanced the crowd's ability to organize and adapt to their environment to reach their social objectives. The US Army, supporting governments abroad or supporting United Nations Resolutions (UNR) in peacekeeping efforts may be susceptible to even a small percentage of a population that is disaffected or dissatisfied by their current situation or government. Lieutenant Colonel Daniel T. Canfield, a Marine Corps Infantry officer, remarked in the *Small Wars Journal,* "in the warm afterglow of Operation *Desert Storm*, our infatuation with technology and its seemingly unbounded potential to revolutionize armed conflict fueled illusions of military supremacy. In reality, however . . . it only demonstrated to our adversaries that the means and methods for confronting the United States would have to change."[151]

Proliferation of mobile devices and social media networks has empowered individuals in a way that has not been possible in the past. As central governments loose national power to groups, individuals, and transnational organizations, the potential for mass mobilization will

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[150] *Operational Environments to 2028: The Strategic Environment for Unified Land Operations*, 48, 40, 41.

[151] Daniel T. Canfield, "Winfield Scott's 1847 Mexico City Campaign as a Model for Future War," *JointForces Quarterly* 55 (Fourth Quarter 2009): 96.

continue to grow. The future operating environment, according to Army Techniques Publication (ATP) 3-39.33, *Civil Disturbances*,

> will require sizable and sustainable expeditionary power projection. Once U.S. forces arrive in theater, they will likely encounter a shrewd and determined enemy employing a hybrid combination of conventional and irregular threats. American ground forces will be outnumbered on most future battlefields and will almost certainly find themselves dwarfed by an ambivalent or potentially hostile indigenous population. Our future commanders will be called on to win quickly at the lowest possible cost in life and treasure.[152]

The US Army may be able to use insights from the principles outlined in complexity theory to better understand, anticipate, and even exploit the threat caused by mass mobilization facilitated by social media.

As complexity theory teaches us, emergent properties and dynamic changes inherent in complex adaptive systems may make predicting specific events or actions impossible. Still, the US Army needs to prepare for what its own TRADOC G-2 anticipates as the future operating environment. As the Army endeavors to better understand the threat posed by social media-driven mass mobilization, it may need to develop ways to combat the threat, working as an agent as part of the complex adaptive system, rather than attempting to eliminate it from the outside.

Social unrest will likely continue throughout the world. Recent events in the United States, specifically in Ferguson, Missouri provide a current example of a state's National Guard responding to demonstrators and rioters.[153] The US Army needs to understand how people and organizations use social media to facilitate mass mobilization. As groups using social media mirror characteristics of complex adaptive systems, principles of complexity theory can provide a useful guide for military planners attempting to understand, anticipate, and exploit the potential threat. Properties common to complex systems, including simple components or agents, nonlinear

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[152] Army Techniques Publication (ATP) 3-39.33, *Civil Disturbances* (Washington, DC: Government Printing Office), 2014.

[153] Monica Davey, John Eligon, and Alan Blinder, "Missouri Tries Another Idea: Call In National Guard," *New York Times*, August 18, 2014, accessed March 15, 2015, http://www .nytimes.com/2014/08/19/us/ferguson-missouri-protests.html?referrer=&_r=0.

interactions among components, absence of central control, and emergent behaviors provide a scientific lens for analyzing the potential threat. Elements of self-organization can help planners understand how a group, without a clearly defined command structure and subordinate commanders, can move toward a common goal. When planners view emergent behaviors at the operational level, they can find ways of anticipating how the threat might act in the future, and planners can find creative ways to exploit the properties of networks inherent in complex adaptive systems.

One of the common properties of systems, absence of central control provides a useful way to understand how social media and mass mobilization operates, independent of a formal command structure. Properties of self-organization that include clustering, flocking and schooling, task allocation, and decision-making illustrate how self-organized groups have proven to be surprisingly resilient to external actions, developing ways to combat external threats as a group that exceed the ability of individual components of the system. With distributed control and using social media networks to facilitate organization, disaffected groups can surprise an unsuspecting government or security forces by mobilizing larger groups of people than were possible in the past, and at much faster speeds. They use clustering to identify potential threats sooner and protect individuals from external threats. Characteristics of flocking and schooling exist in both the physical realm as well as the digital realm for activists. As part of a larger group, whether in a square or online, individuals can be more efficient at reaching objectives that would be difficult or impossible for the individual to attain on their own. Moving with a group increases the bandwagon effect potential, giving more credibility to the movement and decreasing individual security concerns. More interactions take place in large groups of people, leading to better samples among individuals, and better statistics that allow for more efficient task allocation. Individuals in large groups can shift tasks, as required, based on their interaction rates, and help the group at large to accomplish larger objectives. The group can decide on how to achieve those larger objectives without the need for a central authority figure or a consensus.

Using quorum sensing, large groups of people can make decisions, without significantly sacrificing the quality of the decision and still decide in a relatively short period of time. The characteristics of self-organization offer a way for planners to understand how groups of people can organize and rally towards a goal without central control. Understanding these characteristics provide a basis for anticipating how the system might produce patterns of interaction in the future.

Another property of systems is emergent behavior. Organizations at the agent level can appear to move into the realm of chaos, but when the system produces emergent behavior, such as information processing, hierarchical organizations, dynamics, or evolution and learning, the complex adaptive system can produce patterns of behaviors that planners, aware of this fact, may be able to anticipate. Groups process information inside of the group through multiple interactions and find ways to push that information to international audiences to undermine their government. The ability for a government to convey a narrative unimpeded is almost impossible with current mobile electronic devices and social media. The emergence of a hierarchical organization in a system often enables or promotes survival of the system in an erratic environment. Whereas large groups had to rely on information distributed in the group through word of mouth in the past, modern mass mobilization uses social media to spread information rapidly using a hierarchical system. They use a combination of various social media networks to gather important information from the group, convince people in and outside of the country of the worthiness of the cause, and connect with those on the sideline to increase participation. Dynamics in the system show how the system changes over time and allows groups interested in contentious politics to react to an unpredictable environment, sometimes reverting to previous methods of interaction to adjust to the changing environment or threat. A planner should expect the organizations to learn and adapt to their environment, and should expect new patterns of behavior intended to increase the system's resiliency to develop over time.

Network properties under the umbrella of complexity theory provide potential ways of exploiting the networks and organizations. Small world properties, long-tailed degree distribution, clustering and community structure, vulnerability to targeted hub attacks, and vulnerability to cascading failures provide some common network principles that allow for exploitation of the system. The conceptual examples of ways to exploit the system and network listed earlier merely provide possible ways of exploiting an organization under each of these principles. There are ways to exploit organizations developed through the combination of mass mobilization and social media that depend on the specific situation and the context surrounding their formation.

The US Army may be able to use principles of complexity theory as a lens to gain insight into understanding potential threats using characteristics of self-organization, anticipate using common emergent properties, and exploit using properties of networks that are inherent in complex, adaptive systems. Using complex systems thinking, the Army may be able to develop unique operational approaches to solve problems in an increasingly complex environment.

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